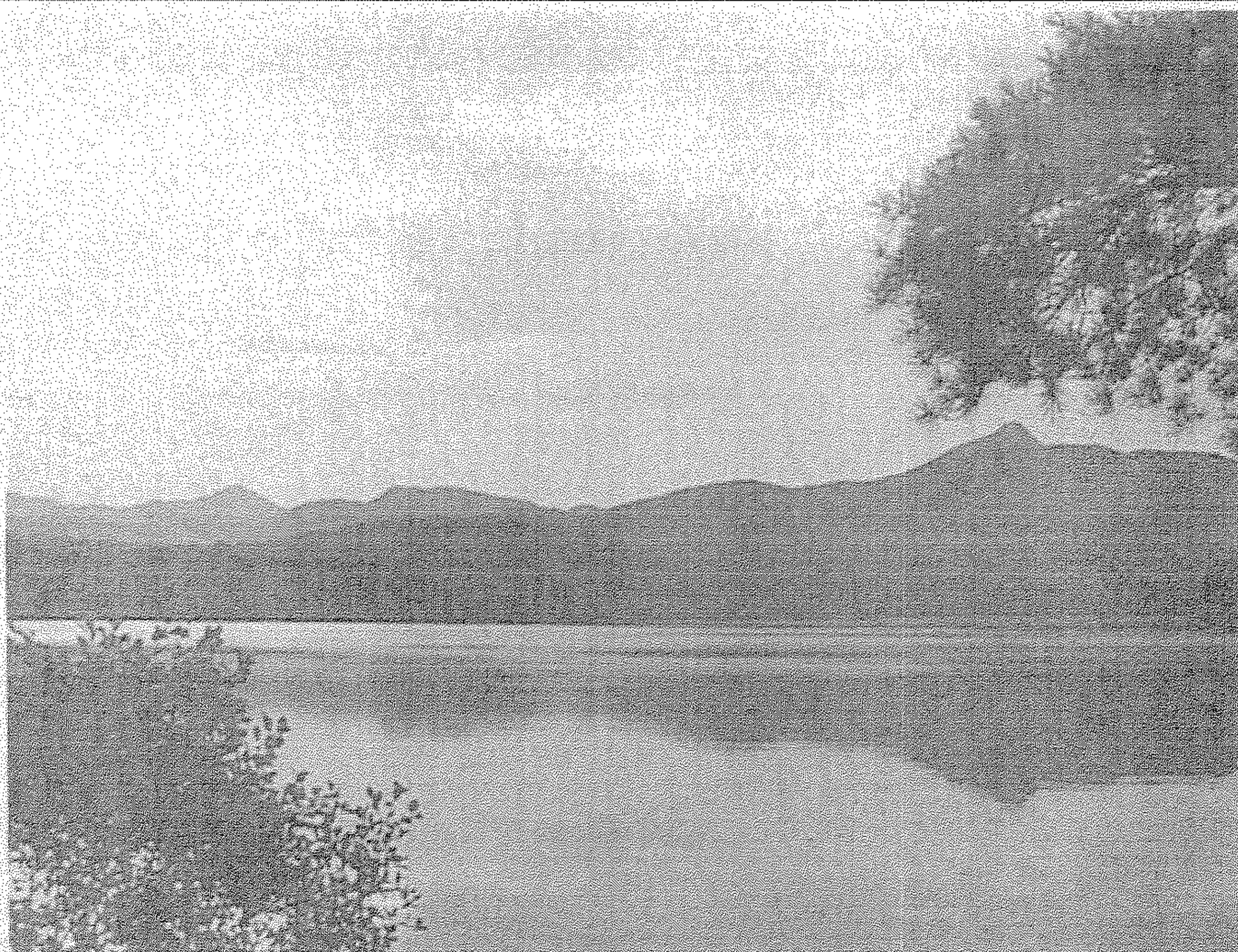
CHOCORUA WATERSHED PROJECT PHASE II SUMMARY REPORT DECEMBER 31, 2003



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Center for Freshwater Biology
University of New Hampshire

UNIVERSITY *of* NEW HAMPSHIRE
COOPERATIVE EXTENSION

To obtain additional information on the NH Lakes Lay Monitoring Program (NH LLMP) contact the Coordinator (Jeff Schloss) at 603-862-3848 or Assistant Coordinator (Bob Craycraft) at 603-862-3696.

Chocorua Watershed Project Phase II Summary Report

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December 31, 2003

Executive Summary
Chocorua Watershed Project Phase II Report

Task I- Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts (Results and BMP Effectiveness).

Key Findings/observations:

- The total phosphorus concentrations documented in the Route 16 drainage culverts prior to BMP implementation (1997, range 25 to 245 parts per billion) were significantly higher than the post BMP total phosphorus concentrations (2003, 2 to 38 parts per billion).
- The spring total phosphorus loading was reduced in Culvert B (a treatment culvert), which constituted our primary comparison site due to the most complete set of water quality data. Even with the marked increase in spring 2003 precipitation, compared to 1997, the spring 2003 total phosphorus loading values were significantly lower than the 1997 data and maintained an average 92% reduction (Figure 9). In addition, the 2003 spring total phosphorus loadings represented a 60% reduction, even when compared to the initial post-BMP installation total phosphorus loading values measured in 2000.
- The greatest total phosphorus (226 *u*g/L), turbidity and TSS measurements were documented at the control site, MH-1 Rt16 (no BMPs), during the 2003 study period and reached levels considered more typical of an impaired system.
- Total suspended solids were low at the treatment culverts in 2003 and remained near or below detectible limits.
- Turbidity was generally low and generally measured less than 1 NTU during the spring and summer sampling period.
- The natural detention basin located in the McGregor Hill Culvert was highly effective at attenuating nutrients during the intense, September 23, 2003 storm event. The water quality data suggest BMPs should be implemented at this site to assure maximum nutrient attenuation in the future.
- Total phosphorus and total nitrogen were higher late in the season and reflected natural increases in organic matter and nutrient loading (total phosphorus and total nitrogen) during periods of high discharge.
- Significant amounts of organic debris (leaves and twigs) collected in the Route 16 drainage culverts in the spring and fall and thus a regimented culvert cleaning schedule should be implemented to maximize the efficiency of the implemented BMPs.

The Post BMP installation Monitoring/Evaluation component of the Chocorua Watershed Project Plan (CWPP) included the collection of water quality data on six sampling dates. The CWPP included early and late spring water quality sampling, as well as, late summer and early fall water quality sampling (Table 1). Generally speaking, the culverts where BMPs had been implemented appear to have been effective attenuating nutrients and sediments as noted under key findings/observations and further documented in the summary water quality data that follows:

Table 1: Storm Event Sampling 2003

Date	04/26/03	05/12/03	06/01/03	09/04/03	09/23/03	10/15/03
Precipitation	1.65"	.84"	.27"	1.48"	1.56"	1.96"
Description	Steady rain Snow melt	Post Storm	Drizzle	Drizzle	Heavy Rain (Flush)	Drizzle

- Data measured at the Tamworth4 Climatological sampling station: 71°16' latitude, 43°52' longitude, elevation of 158.5 feet.
- Daily precipitation data are measured at 0700 hrs. The data presented in Table 1 reflect a composite of the measurements collected on the respective sampling date and the following morning to most accurately reflect the amount of rainfall during each sampling event.

Spring Water Quality Data (2003)

The 2003 total phosphorus concentrations were generally low and below 10 parts per billion in the treatment (implemented BMP) culverts during the April 26, May 12 and June 1 sampling dates. Furthermore, the total phosphorus concentrations measured at the treatment sites were similar to reference total phosphorus concentrations measured at the Chocorua River #1 sampling site that is drained by a "pristine" forested watershed. Several samples collected in Culvert A exceeded 10 ppb (max value of 12.6 ppb) on April 26 and May 12 and were likely associated with organic debris that is naturally flushed through this culvert system.

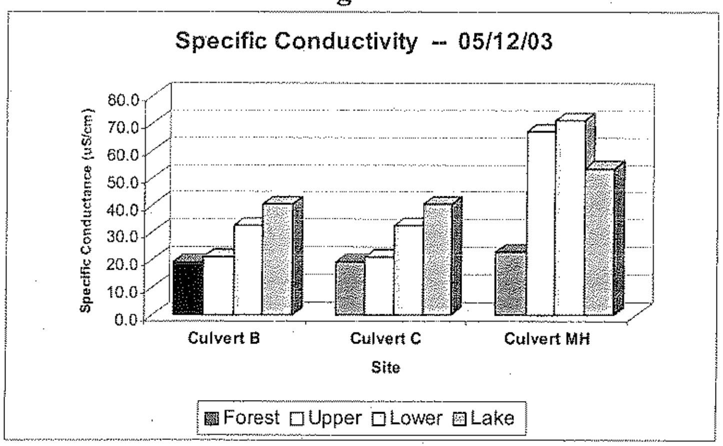
Samples collected at the control culvert at McGregor Hill Road included some values that were significantly higher than the corresponding total phosphorus concentrations measured in the treatment culverts. Effluent from a pipe that drains Route 16 reached 55.9 ppb on April 26 and was over four times higher than the total phosphorus concentrations documented in Culvert A. On most sampling dates, a film of organic material, likely sewage fungus, coated the Route 16 drainage culvert but was absent from the treatment culverts. Such growth is an indicator of increased nutrient loading.

Turbidity data collected at the Route 16 drainage culverts remained below 1.0 Nephlometric turbidity units at all treatment culverts on April 26, May 12 and June 1, 2003 and at the control culvert, McGregor Hill, on May 12 and June 1, 2003. The highest spring 2003 turbidity measurements were documented at McGregor Hill culvert on April 26, 2003 and reached 9.2 NTU at the Route 16 discharge culvert. However, the turbidity did decrease to 2.0 NTU at the upper sampling site and was further reduced to 1.1 NTU at the lower sampling site adjacent to Little Chocorua Lake. The high turbidity coincided with high total suspended solids measurements in the McGregor Hill Road Culvert on April 26, 2003 and measured 14.5 milligrams per liter (mg/L) at the Route 16 discharge culvert, 3.6 mg/L at the upper site and 2.1 mg/L at the lower site.

Total suspended solids measured at the treatment culverts in 2003 were generally below detectible limits and reflected stable culvert channels that minimized erosion. Alternatively, significant sediment washout was observed in 1997, prior to the BMP implementation, during the Chocorua Lake water/nutrient budget. The total suspended solid documented in the "reference" forest drainage in Culvert C (site C-1 Forest) measured 3.0 mg/L on May 12 and June 1, 2003 but remained below detectible limits at the upper and lower sampling points. The turbidity documented at the lower Culvert A sampling site (A-3) measured 4.0 mg/L on April 26, 2003 but did not suggest water quality problems in Culvert A at that time. Interestingly, there is not a distinct culvert channel between the upper and lower sites; the water becomes un-channeled runoff that spreads out and becomes diffuse flow before reaching the lake. The diffuse nature of this stream allows a significant amount of inorganic particulates (i.e. sediments) to settle out before reaching the lake as evidenced during visual inspection of the site. However, there is a lot of fine particulate organic matter (i.e. decomposing deciduous leaves) that can become suspended in the water and washout into Chocorua Lake. Fine particulate matter was commonly observed in water samples collected as the water flowed from Culvert A into Chocorua Lake. Such a washout, however, is a natural occurrence and does not reflect poorly functioning BMPs but rather reflects the natural cycling of organic debris from the uplands into the lake.

The spring specific conductivity (a surrogate for road salt) data exhibited a general trend of increasing values from the forested (reference sites) to the upper and lower sampling locations that are potentially impacted by the Route 16 runoff as exemplified in Figure 1. Due to the highly soluble nature of sodium and chloride, the increasing specific conductivity values downstream of Route 16 can be expected. Furthermore, the Best Management Practices (berms and swales) constructed as part of this project were only intended to attenuate the sediment load and nutrients, and thus, the specific conductivity measurements should not be interpreted as a failure of the implemented BMPs but rather as an indicator of road salt applications adjacent to Chocorua Lake.

Figure 1.



Late Summer/Fall Water Quality Data

Total phosphorus concentrations measured on September 4, September 23 and October 15 commonly exceeded the concentration of 10 parts per billion (ppb) in both the treatment and control culverts. The September and October sampling dates were characterized by high flow periods coupled with the senescence of deciduous leaves that increased the organic matter load to each of our study culverts. Furthermore, the water quality data collected on September 23, 2003 reflected the impact of an intense storm event on our study culverts that translated into some of the higher

Table 2: Culvert Discharge expressed as Liters/minute.

	Culvert A (Liter/min)	Culvert B (Liter/min)	Culvert C (Liter/min)	Swale (Liter/min)	MH Culvert (Liter/min)	Rt 16 Culvert (Liter/min)
4/26/03	-----	465.6	1777.0	77.1	1502.5	164.0
5/12/03	238.0	335.2	390.4	-----	888.9	-----
6/01/03	82.3	59.3	-----	-----	165.7	51.3
9/04/03	436.5	268.4	-----	-----	264.3	-----
9/23/03	1574.8	1161.1	1911.6	-----	3908.8	1854.7
10/15/03	748.5	983.1	2715.2	-----	1493.2	96.6

discharge and phosphorus loading values documented during our study period (Table 2).

Elevated total phosphorus and total nitrogen concentrations were documented in each of the flowing culverts (Culverts A, B, C and MH) during the months of September and October as represented by the comparison of the early season (April 26) and September 23 total phosphorus data (Figures 2 & 3). Nitrogen concentrations in forested watersheds are commonly associated with nitrogen that leaches naturally from decaying vegetation such as leaves and coarse woody debris. Considering the total nitrogen concentrations were high in each culvert's "reference" forested site, upstream of Route 16 (Figure 2), the elevated late season total nitrogen concentrations appear to reflect loading from natural nitrogen sources. Organic debris (i.e. leaves and twigs) also contains a significant amount of phosphorus and appears to have contributed to the elevated total phosphorus concentrations documented in September and October. Inorganic debris, such as sand and silt, can

Figure 2.

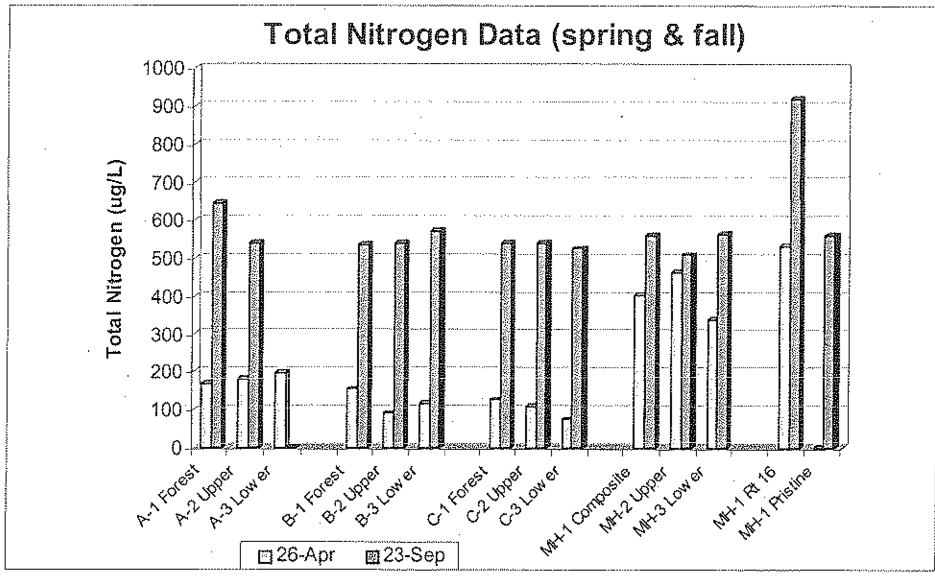
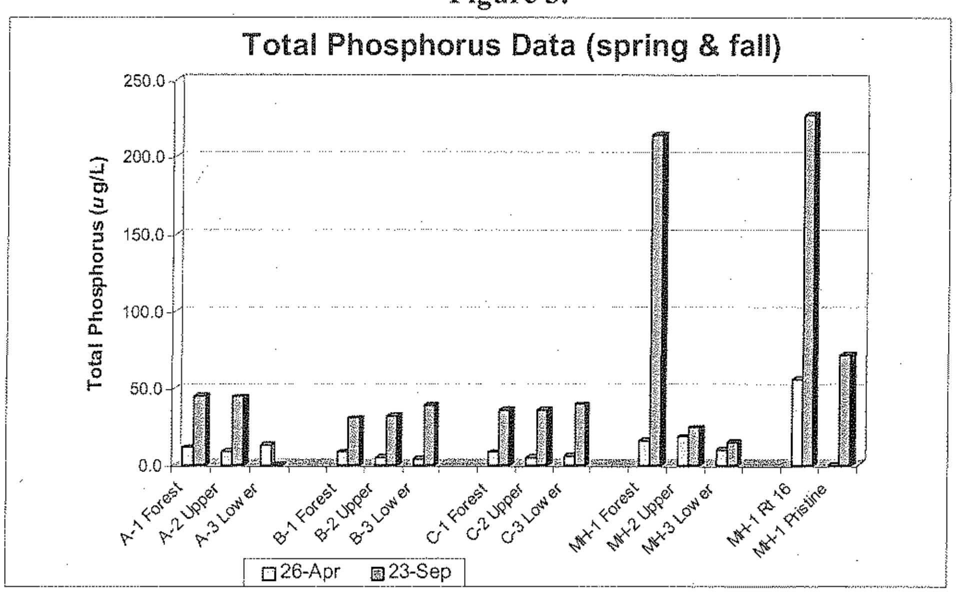


Figure 3.



also be a significant source of phosphorus and was considered a primary source of the total phosphorus loading from the Route 16 drainage culverts prior to BMP implementation. When water quality samples were collected during the 2003 sampling season, water samples were visually inspected for the presence of organic and inorganic particulate matter.

Data recorded by the CFB field technicians identified significant amounts of organic matter in many of the September and October samples while inorganic matter was not detected visually. Quantitative total suspended sediment samples, collected concurrently with the total phosphorus and total nitrogen data, were generally near or below detectible limits and reflect insignificant amounts of inorganic matter (i.e. heavy loading of sediments and sand would be detectible as significantly higher TSS values). Of the three late season sampling dates, the September 23, 2003 TSS data generally exhibited the highest values and corresponded to the highest total nitrogen and total phosphorus concentrations documented in the respective culverts. Similarly, the highest turbidity values were generally documented on the September 23, 2003 sampling date and reflected elevated levels of organic debris caught in the culvert discharges.

The two highest total phosphorus concentrations measured during this study were documented on September 23, 2003 at the MH-1 (Composite) site, 213.8 ppb, and the effluent from Route 16 that drains into the McGregor Hill culvert, 226.9 ppb (Figure 3). The McGregor Hill culvert represents a control site where no BMPs were implemented and the data continue to reflect poorer water quality at the Route 16 drainage, relative to the treatment (implemented BMP) sites.

The fall specific conductivity values were similar among the three in-culvert sampling sites (Forest, Upper and Lower) and suggest the sodium and chloride had flushed through the system during the spring and summer months.

BMP Effectiveness (2003)

Data documented through this study suggest the BMPs implemented along Culverts A, B and C, as well as, the "Swale" were effective at mitigating the problems associated with the excessive sediment loading that was documented during the 1996-1997 Chocorua Lake water/nutrient budget. The highest level of phosphorus loading was documented at the control, Rt 16 Culvert, that reached 420 grams per hour on September 23 and where the phosphorus loading was over five times greater than at Culvert C (a treatment culvert), where the second highest phosphorus loading value of 75 grams per hour was documented (Table 3).

Table 3: Total phosphorus loading by Culvert expressed as grams phosphorus/hour.

	Culvert A * (grams/hr)	Culvert B * (grams/hr)	Culvert C * (grams/hr)	Swale * (grams/hr)	MH Culvert * (grams/hr)	Rt 16 Culvert * (grams/hr)
4/26/03	-----	1.9	9.8	0.2	14.3	9.2
5/12/03	2.8	1.8	3.2	-----	4.0	11.9
6/01/03	-----	0.4	-----	-----	0.4	0.1
9/04/03	-----	7.0	-----	-----	3.8	-----
9/23/03	-----	45.5	75.0	-----	56.2	420.3
10/15/03	18.6	25.7	81.9	-----	28.3	1.6

* loading values calculated for the Lower sampling sites to reflect the phosphorus load into Chocorua Lake.

A phosphorus loading inter-comparison among the three culvert sampling points (Forest, Upper and Lower) indicated the phosphorus loading values were generally similar among the three sampling locations in the respective culverts. When large differences were documented, the

Table 4: Total phosphorus loading by Culvert and location (forest, upper & lower) expressed as grams phosphorus/hour.

	Culvert B 4/26/03 (grams/hr)	Culvert B 5/12/03 (grams/hr)	Culvert B 9/23/03 (grams/hr)	Culvert B 10/15/03 (grams/hr)
Forest	3.9	2.4	35.1	21.2
Upper	2.3	1.4	37.1	20.6
Lower	1.9	1.8	45.5	25.7
% chg **	-51%	-25%	+23%	+18%
	Culvert C 4/26/03 (grams/hr)	**Culvert C 5/12/03 (grams/hr)**	**Culvert C 9/23/03 (grams/hr)**	**Culvert C 10/15/03 (grams/hr)**
Forest	14.7	2.8	67.8	91.4
Upper	8.2	2.5	69.1	80.5
Lower	9.8	3.2	75.0	81.9
% chg **	-33%	+13%	+10%	-10%
	Culvert MH 4/26/03 (grams/hr)	**Culvert MH 5/12/03 (grams/hr)**	**Culvert MH 9/23/03 (grams/hr)**	**Culvert MH 10/15/03 (grams/hr)**
Forest	23.9	4.6	834.7	29.7
Upper *	27.5	5.4	94.9	30.9
Lower	14.3	4.0	56.2	28.3
% chg **	-40%	-13%	-93%	-5%

* Includes influence from the Route 16 effluent culvert (direct Route 16 runoff).
** denotes the % increase/decrease in the phosphorus load from the forested to the lower monitoring station in the respective culverts.

differences reflected a decrease in the phosphorus load that occurred between the pristine (reference) Forest site and the "impacted", lower, sampling site that is located downstream of Route 16 and that is adjacent to Chocorua Lake (Table 4 and Figures 4-6). The total phosphorus concentrations generally decreased as the water flowed towards the lake and the decreases suggest the removal of phosphorus rich particulate matter that is a primary source of phosphorus. However, due to the low levels of total suspended solids (which were commonly below detectible limits) this assertion is based on intuitive reasoning and speculation rather than a reflection of the quantitative TSS data. On the other hand, the lack of significant TSS is an indication that the BMPs are working effectively by stabilizing the culvert banks and maintaining vegetative cover over the upland soils that would otherwise erode into the culverts as was visually documented during the 1996/1997 Chocorua Lake water/nutrient budget.

Total phosphorus data, collected on September 23 in Culverts B and C, and on October 15 in Culvert C, increased as the water flowed towards the lake, during high flow periods, in the fall. The total phosphorus increase might superficially suggest the BMPs were ineffective at attenuating nutrients, however, visual inspection of the runoff indicated a lot of fine organic matter was suspended in the water samples on fall sampling dates while the BMPs were implemented to remove heavy inorganic debris (i.e. sand and sediment), not the lightweight organic debris. Interestingly, a significant amount of coarse leaf debris was "captured" in the rip-rap and plunge pools, however, the decomposing and flaking leaf fragments appeared to be dislodged during these high flow periods and were subsequently flushed into Chocorua Lake. Such organic matter accumulation in the BMP culverts reiterates the importance of a regular maintenance/cleaning

Figure 4.

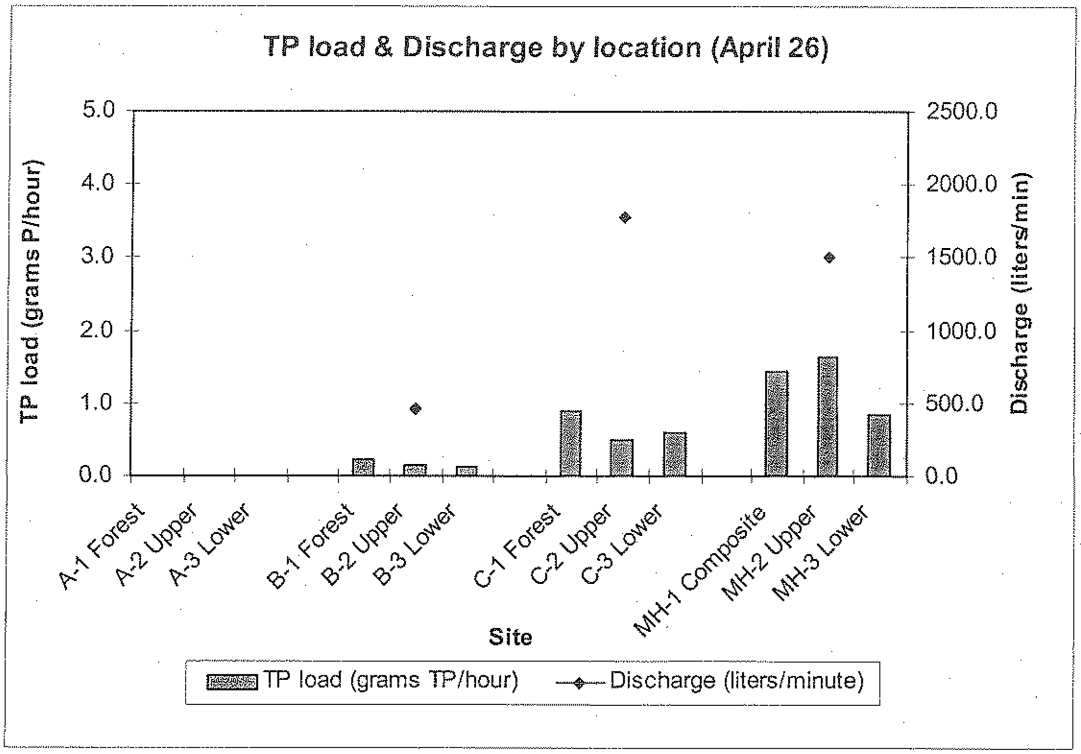


Figure 5.

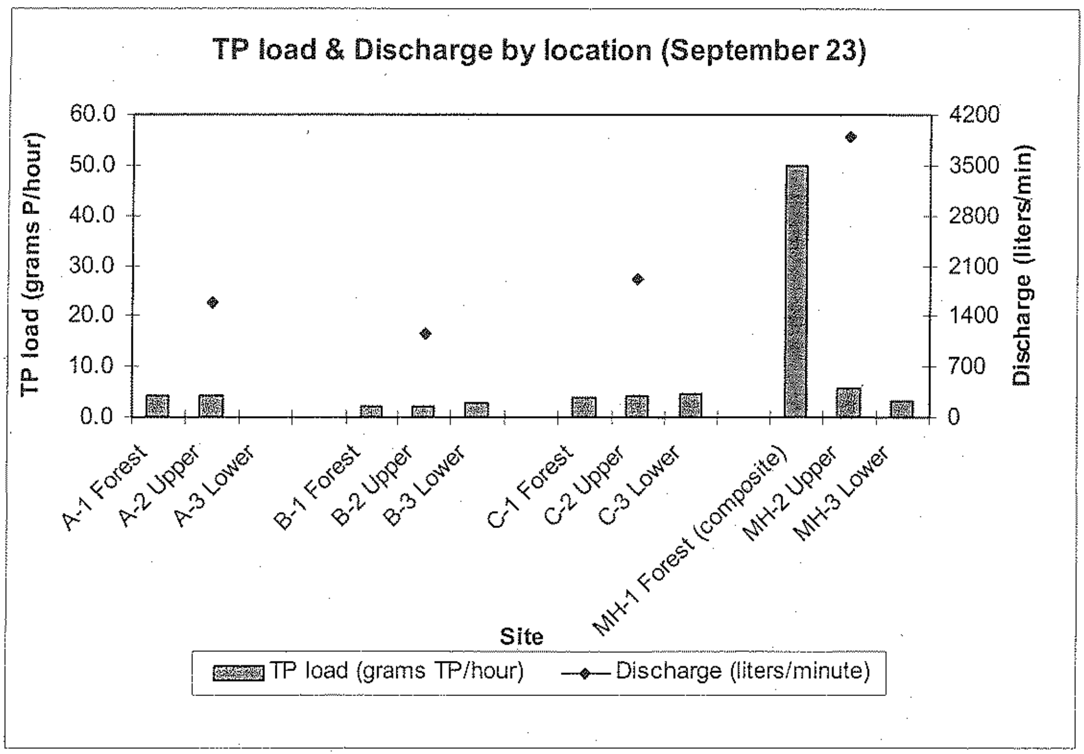
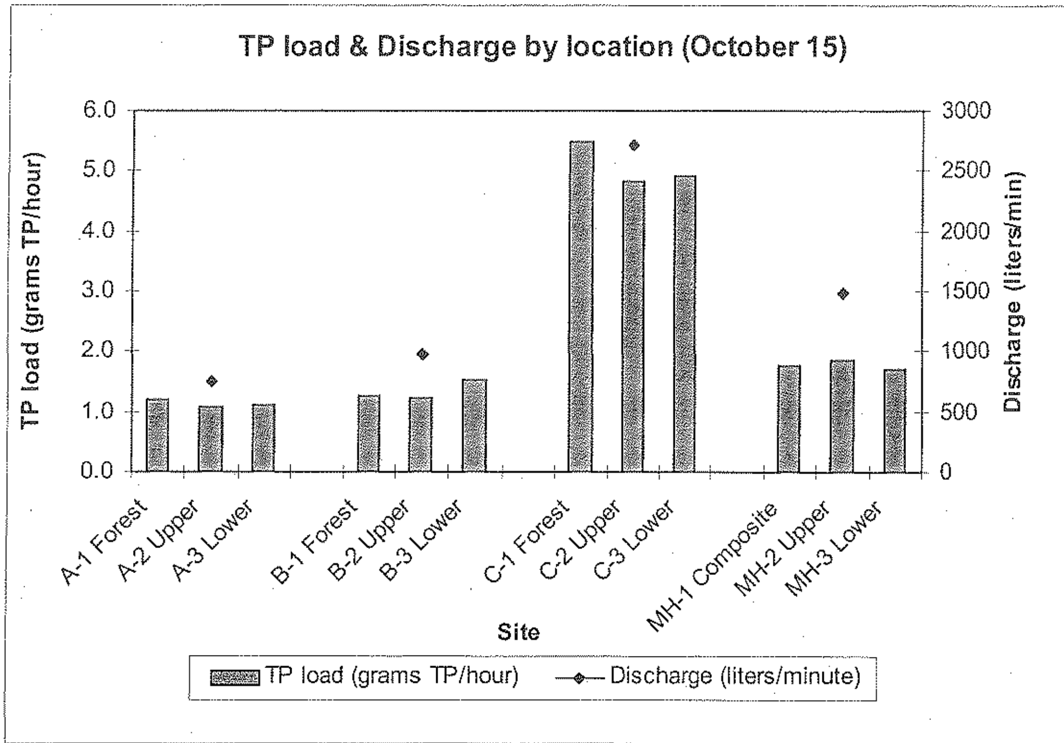


Figure 6.



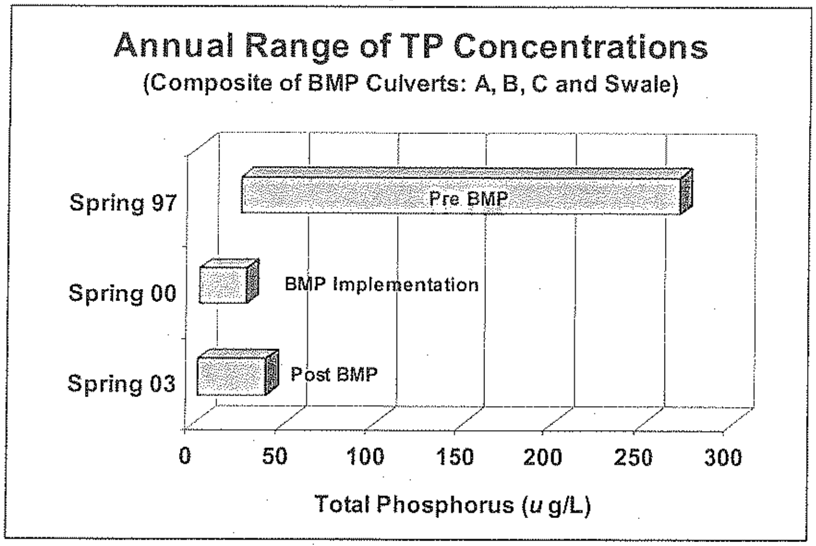
schedule that will assure this material is periodically cleaned out so it does not flush into Chocurua Lake.

Visual inspection of the treatment (BMP) culverts and the surrounding uplands between April and October 2003 did not reveal any sediment/erosion plooms into Chocorua Lake that would indicate the capacity of the BMPs, to effectively attenuate nutrients and sediments, was exceeded. The vegetative cover adjacent to the culverts was sufficient to minimize the erosion of upland soils while the rip-rap and herbaceous root structure in the culvert channels helped hold the in-stream sediments in place. On one occasion, a heavy storm event resulted in a localized sediment ploom into the northern segment of the swale that is located adjacent to the town beach. While the sediment ploom did occur, visual inspection of the swale and outflow into Chocorua Lake suggested the sediments were rapidly attenuated and did not impact Chocorua Lake. Furthermore, the swale culvert was dry on most sampling occasion, even during wet weather periods, and suggests a large percentage of the water entering the lake in this drainage area reaches Chocorua Lake as "purified" groundwater flow.

BMP Effectiveness (Pre and Post BMP implementation comparison: 1997, 2000 & 2003)

A comparison among the total phosphorus data collected prior to BMP implementation (1997), during the early stages of BMP implementation (2000) and following completion of the BMPs (2003) indicates a significant reduction in the range of the annual total phosphorus concentrations collectively reported for the treatment culverts: Culverts A, B, C and the swale (Figure 7). The total phosphorus concentrations ranged from 25 to 245 parts per billion (ppb) prior to BMP implementation (1997), ranged from 2 to 26 ppb during the early stages of BMP

Figure 7.

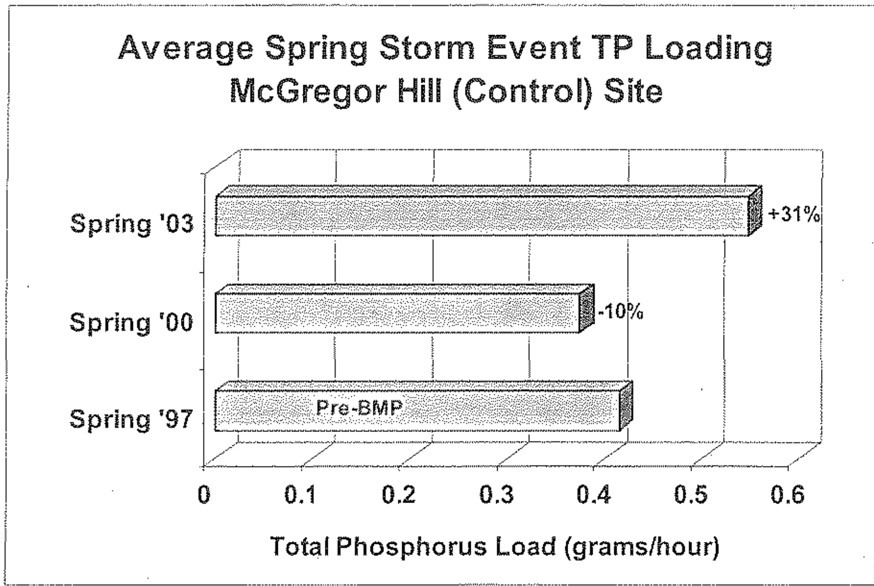


implementation (2000), and ranged from 2 to 38 ppb following full BMP implementation (2003). The decrease in the phosphorus range is largely associated with a corresponding reduction in the suspended sediment load into Chocorua Lake. While total suspended solids were not quantified prior to 2003, historical records indicate significant amounts of sediments were documented in the total phosphorus samples during the 1997 sampling season and corresponded to the high total phosphorus concentrations.

Annual total phosphorus loading values were compared among the three sampling seasons (1997, 2000 and 2003) at the McGregor Hill (control) culvert to help assess the natural variation in the total phosphorus load among the three years. Since no BMPs were implemented in or adjacent to the McGregor Hill culvert, the annual variation documented at this site is assumed to reflect natural variations in phosphorus loading among years. The annual total phosphorus load decreased by 10% in the year 2000 and increased by 31% in 2003, relative to the 1997 loading value, as depicted in Figure 8. Thus, when assessing the effectiveness of the implemented Route 16 BMPs, the annual data will be weighted against the annual precipitation data to account for the natural variations in phosphorus loading that are associated with climatic variables and, while beyond our control, had a profound influence on the annual phosphorus loading values.

A comparison among the pre-BMP implementation (1997), BMP construction phase (2000) and the post-BMP (2003) data was conducted using phosphorus loading values weighted for precipitation as described above. The 2003 spring total phosphorus loading values were significantly lower than either the 1997 (92% reduction) or the 2000 (60% reduction) "normalized" spring phosphorus loading values (Figure 9). During the pre-BMP sampling season (1997) a significant amount of sediment was observed (but not quantified) in the total phosphorus samples while the 2000 and the 2003 samples contained negligible amounts of sediments; the 2003 suspended sediment samples were near or below detectible limits in the treatment culverts. The low suspended sediment levels, documented during the 2003 study season, corroborated the lack of significant sediment load during the post-BMP implementation period.

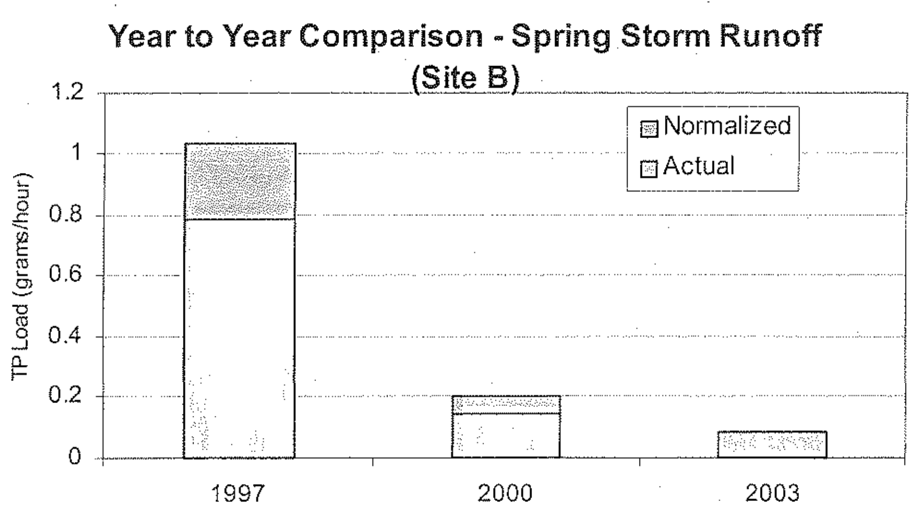
Figure 8.



The spring runoff period is represented by minimal vegetative cover and high flow periods associated with snowmelt and a saturated water table. Thus, the spring runoff period is oftentimes characterized by a high potential for sediment washout and increased nutrient loading potential, particularly when erosion control measures are not in place in sensitive areas.

A second comparison was undertaken between the 1997 and 2003 "normalized" spring and fall phosphorus loading data to further assess the effectiveness of the Route 16 BMPs. *Note: limited rainfall during the fall of 2000 limited the late season runoff and thus the BMP construction phase (2000) data were excluded from this comparison.* The composite of the spring and fall water quality

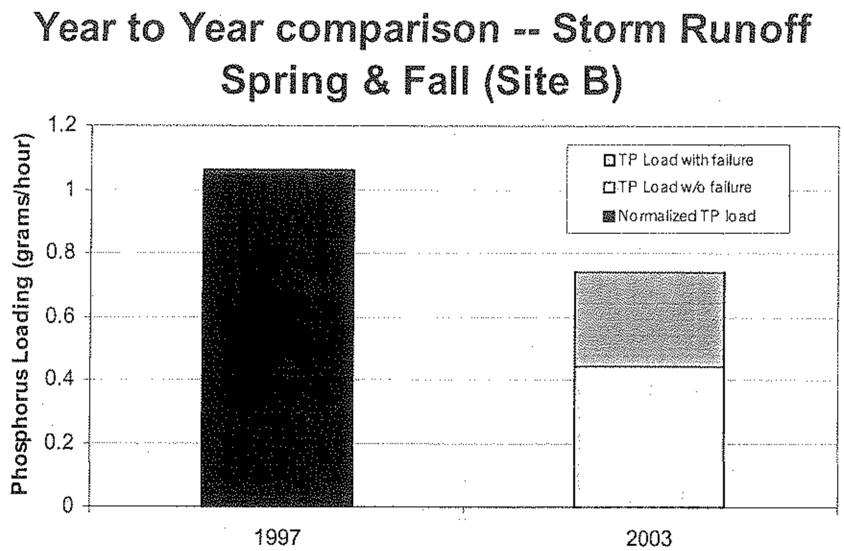
Figure 9.



The 2003 spring total phosphorus loading represents a 92% reduction in spring storm event loading relative to 1997 and a 60% reduction relative to 2000.

data revealed a 30% reduction in the annual phosphorus load when comparing the pre-BMP (1997) and the post-BMP (2003) data (Figure 10). An intense, September 23, 2003, storm event accounted

Figure 10.

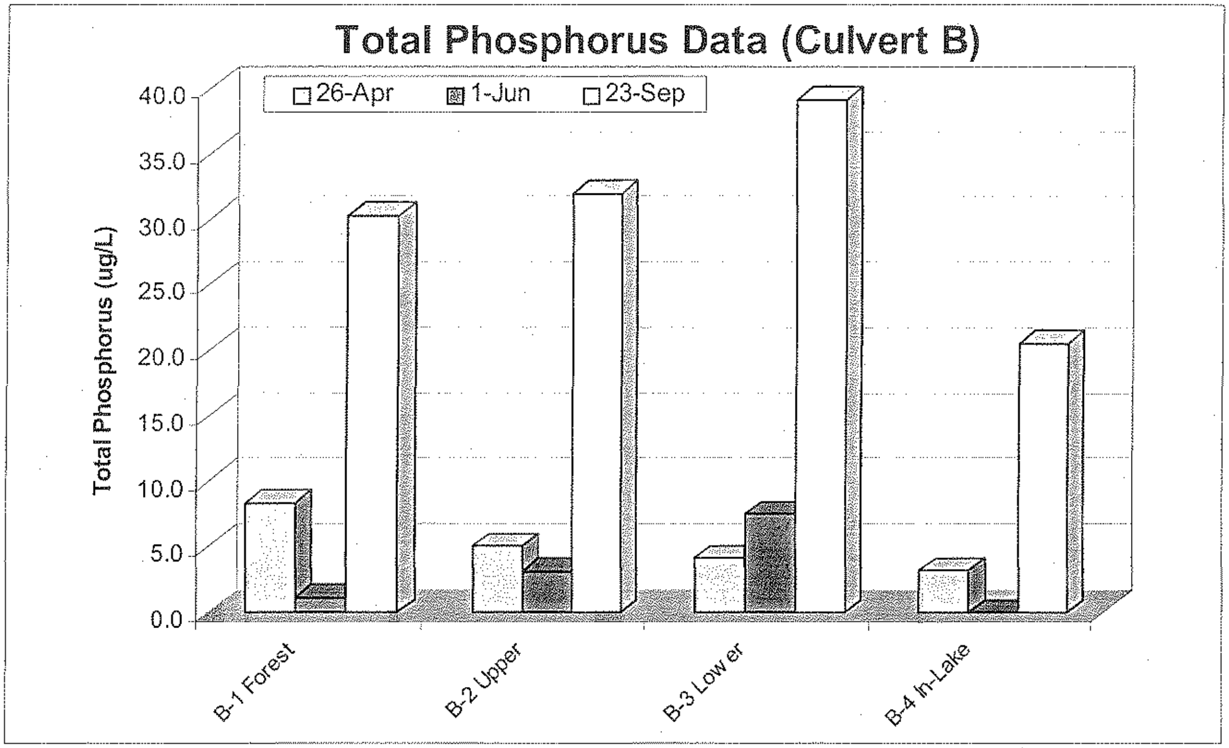


A comparison between the 1997 and 2003 phosphorus loading data indicate a 30% reduction in the phosphorus load. If the September 23, 2003 storm event (TP load with failure) is removed from the analysis, the data indicate a 58% reduction in the phosphorus loading between the pre and post BMP monitoring data.

for a significant amount of the phosphorus load and reflected a storm event that exceeded the capacity of the Route 16 BMPs to attenuate the nutrient load (Figure 11). If the anomalous nutrient loading data from the September 23, 2003 storm event are removed from the pre and post-BMP comparison the data indicate a 58% reduction in the phosphorus loading values (Figure 10). The fall 2003 water quality data reflect a worse case scenario for sediment and nutrient loading due to the saturated soil conditions that coincided with atypically high rainfall, coupled with intense storm events that occurred in September and October, 2003. The result was an atypically high runoff period in 2003 during which, even with the implemented BMPs, the discharge volume exceeded the capacity of the BMPs to attenuate nutrients. On the other hand, the 30% reduction in the 2003 phosphorus load is testament to the effectiveness of the BMPs even through the discharge volumes at times exceeded the BMP capacities.

The BMP nutrient attenuation efficiency was reduced when the fall water quality data were incorporated into the comparison. The fall data were collected when significant vegetative cover characterized the drainage basin and when deciduous leaf senescence was occurring. The 2003 fall water quality samples consistently contained organic debris (i.e. decomposing leaf debris) that appears to have contributed to the reduced efficiency of the BMPs at attenuating nutrients. The rip-rap, and plunge pools are very effective at removing inorganic debris such as sand and other relatively heavy inorganic particles. On the other hand, the organic debris is light and is more likely to remain suspended in the streamflow and enter Chocorua Lake. Thus, it appears the reduced efficiency of the BMPs in the fall are associated with the natural shift in particulate debris from "heavy" sediment rich effluent, that is rapidly attenuated by the BMPs, to a mix of lighter organic and inorganic particles, much of which will reach the lake before being attenuated. While seasonal fluctuations in the BMP effectiveness do exist, the data that were collected in the Route 16 culverts indicate the erosion control measures have been quite effective at mitigating the historical sediment washout problems.

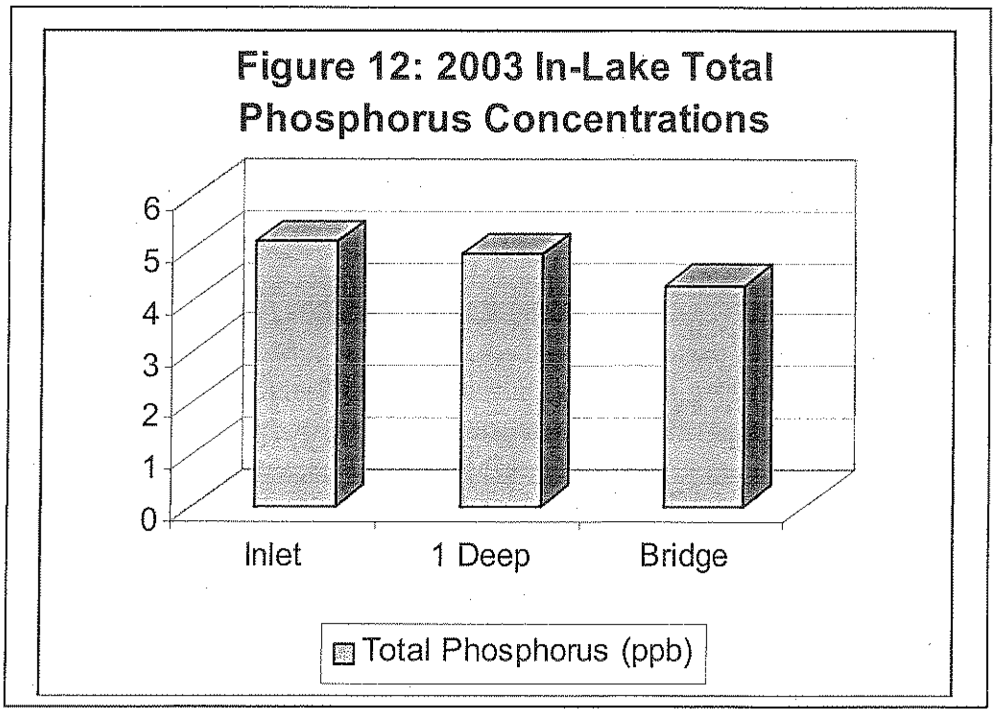
Figure 11.



Task II - Deep Lake and Major Tributary Sampling.

In-lake total phosphorus concentrations were measured at the Chocorua River Inlet, the deep centrally located sampling station, Site 1 Deep, and at the Chocorua Lake outlet 30 meters upstream of the Bridge between Chocorua Lake and Little (Chocorua) Lake. The total phosphorus concentrations were measured to provide a better idea of the "flow through" of phosphorus from the primary source (Chocorua river) to the outlet at the Bridge. Variations in phosphorus among the three sampling locations will provide some information on the potential retention of phosphorus in Chocorua Lake; a reduction in the total phosphorus concentrations between the Chocorua River and the Bridge would be assumed to constitute phosphorus deposited/retained in Chocorua Lake.

There was a general decrease in the total phosphorus content among the three sampling locations (Figure 12) that suggests some phosphorus, originating from the Chocorua River, is being deposited into Chocorua. However, the seasonal average in-lake total phosphorus concentrations,



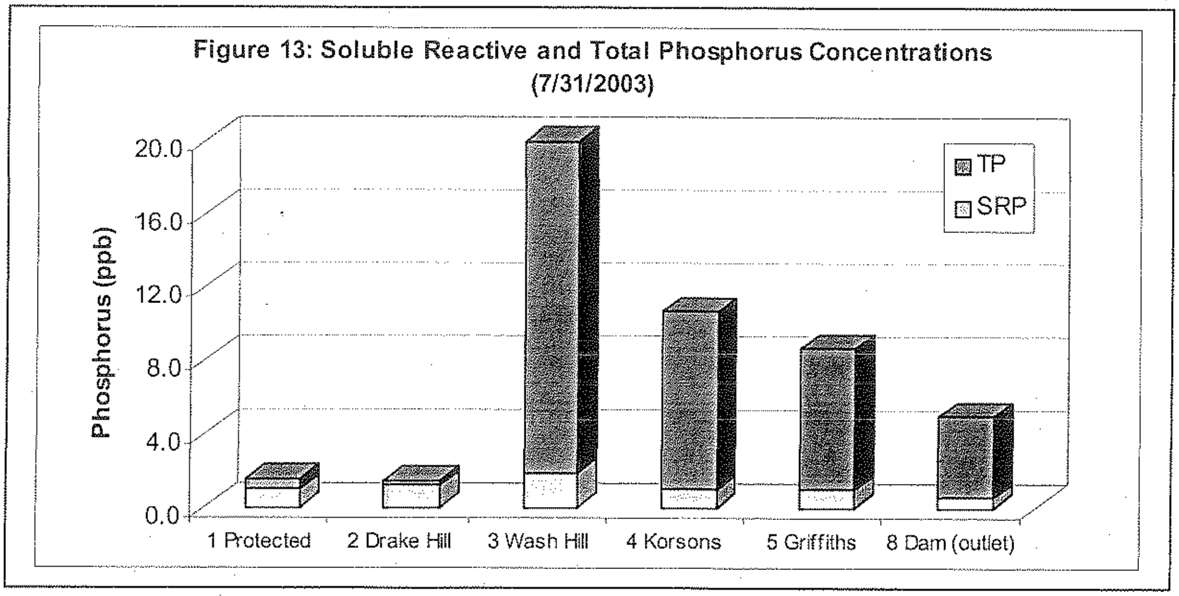
measured bi-weekly by the Chocorua Lake volunteers, were similar among the three sampling locations and did not reach problematic levels. Thus, the retention of some total phosphorus should not be alarming.

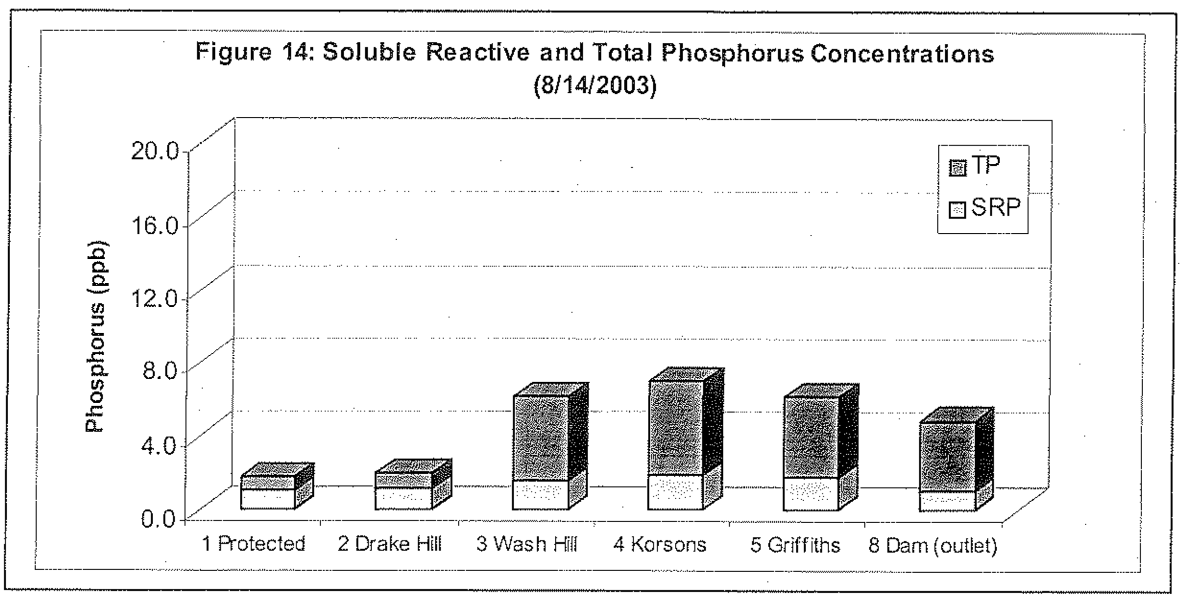
Furthermore, the Chocorua River is just one of many sources (i.e. Stratton Brook, Rt. 16 drainage) of phosphorus into Chocorua Lake and the input of accessory phosphorus, that would provide additional insight into the fate of the phosphorus, was not quantified as part of this study. Water quality data collected during the 1996/1997 Chocorua Lake water/phosphorus budget estimated a 5% retention of phosphorus. Since best management practices were implemented to reduce the phosphorus loading/retention, the phosphorus that is currently deposited in Chocorua Lake is likely near or below the previous figure of 5% retention figure.

Task III - Integrated Nutrient Sampling of Pre and Post Wetland Impacts

Phosphorus Concentrations:

Phosphorus is the limiting nutrient for algae growth in Lake Chocorua and thus was the nutrient of primary concern for this study. The soluble reactive phosphorus (SRP) was sampled to see if the wetland complexes modified this biologically available phosphorus source. SRP was found to be very low throughout the upper Cho7corua River system, only approaching 2.0 *u*g/L (Washington Hill on 7/3/03 & 7/31/03 and Korson's on 8/14/03) during the summer. SRP was greatest following the high flow conditions in the summer (August 14) while Total Phosphorus (TP) peaked during the dry summer conditions that preceded the significant summer storms (Figures 13 & 14). Wetland SRP levels were always lower than runoff concentrations documented during



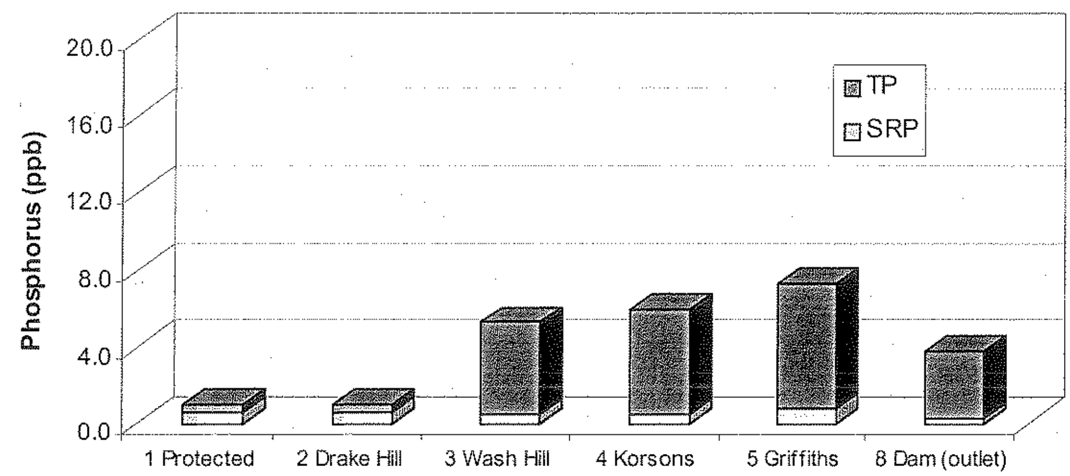


similar periods and indicate the wetlands are effective at sequestering dissolved nutrients.

The Washington Hill site had the greatest average TP levels for the sampling period (9.7 ppb) and the "Protected Area" (upper Route 16) and Drake Hill Road sites had the lowest (1.8 and 1.4 ppb, respectively). This is consistent with our earlier watershed study that determined the pre-BMP Route 16 drainage was the most impaired sub-watershed, while the next area of concern was the low density developed area between Drake Hill Road and Washington Hill Road.

Except for 8/14/03 and 9/11/03 (Figures 14 & 15), the general trend was an increase in total phosphorus at or near the Washington Hill site with a slight decline in concentrations occurring through each successive wetland complex as exemplified by the July 31, 2003 data (Figure 13).

Figure 15: Soluble Reactive and Total Phosphorus Concentrations (9/11/2003)



The median wetland total phosphorus concentrations were comparable to in-lake levels; the in-lake total phosphorus levels fell within the median conditions documented at the tributary wetland sites.

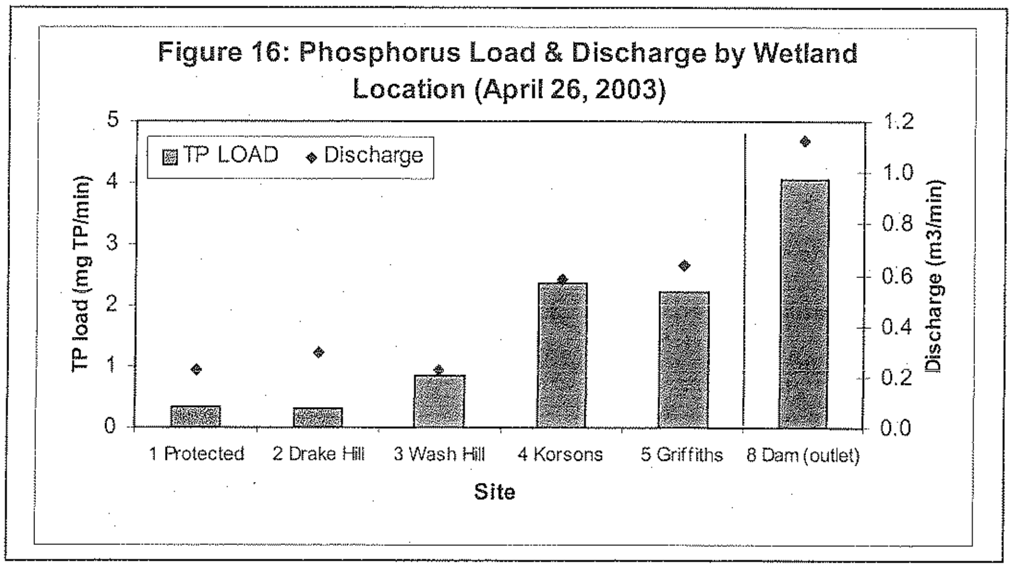
Nitrogen Concentrations (refer to appendix tables):

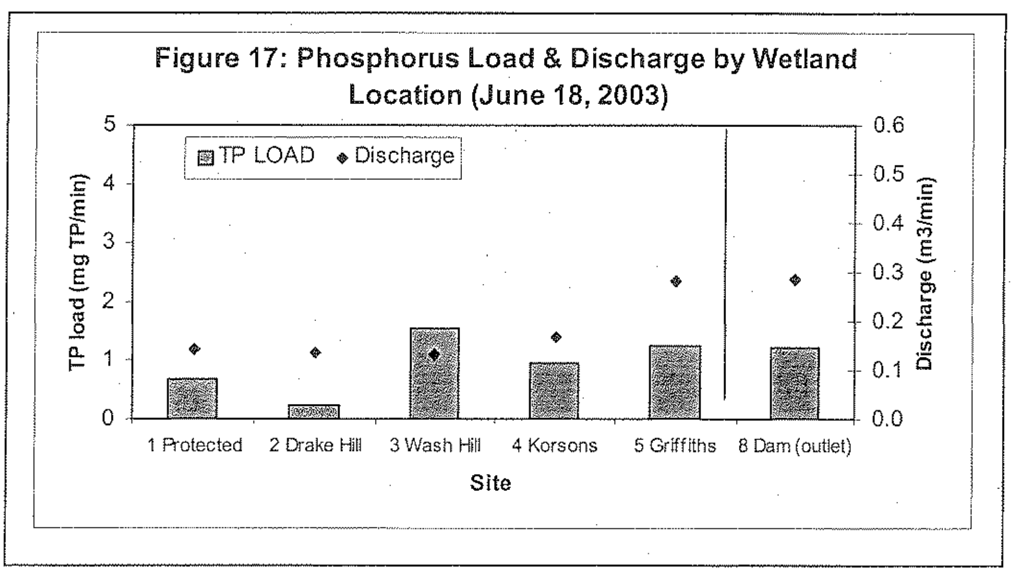
Similar to SRP, Total Nitrogen (TN) peaked during the summer flooding events. This is not surprising given the high mobility of Nitrogen species. The pattern of total nitrogen variation among wetland sites for a given sampling date and the seasonal pattern of total nitrogen concentrations was comparable to the total phosphorus results. The highest average TN throughout the study (194 ppb) was found at the Washington Hill site and the lowest at the "Protected" site (53 ppb).

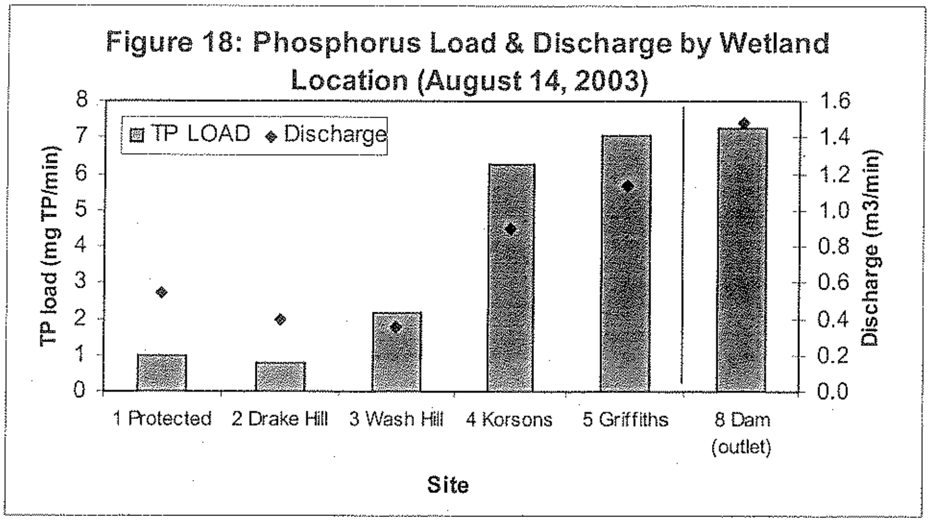
The Nitrogen to Phosphorus Ratio is often studied since low ratios (about 4:1) tend to favor nuisance blue green algae while high ratios (20:1 or greater) favor less problematic green algae dominance. During all sampling dates moderate to high ratios occurred. Late summer/early fall data collected at Drake Hill Road revealed very high N:P ratios during both wet and dry flow conditions, possibly indicating the influence of landscaping practices in the area.

Nutrient Loadings

While nutrient concentrations measured through the river system provide insight into some of the physical/chemical/biological dynamics of the river wetlands, it is the phosphorus loading (concentration multiplied by water flow volume) that will drive the productivity of the lake. We designed the sampling scheme to further explore how the various wetland systems act as sinks, sources and shunts for nutrient loading. This is important since we would expect the nutirent loading to increase as we move down the river corridor that is dominated by a landcover type (i.e. developed) other than wetlands. On all sampling dates the data indicate that the wetlands had a large phosphorus attenuating effect as exemplified by the data depicted in Figures 16 through 18. In fact, for all dates excluding 14 August and 11 September, which represented major and moderate storm flow conditions, there was a significant net loss of phosphorus. As would be expected, wetlands were most successful as nutrient sinks during the driest periods monitored. It is important to note that the upper Chocorua River loading rates were much lower than the unmitigated Route 16 drainage area, McGregor Hill Road.





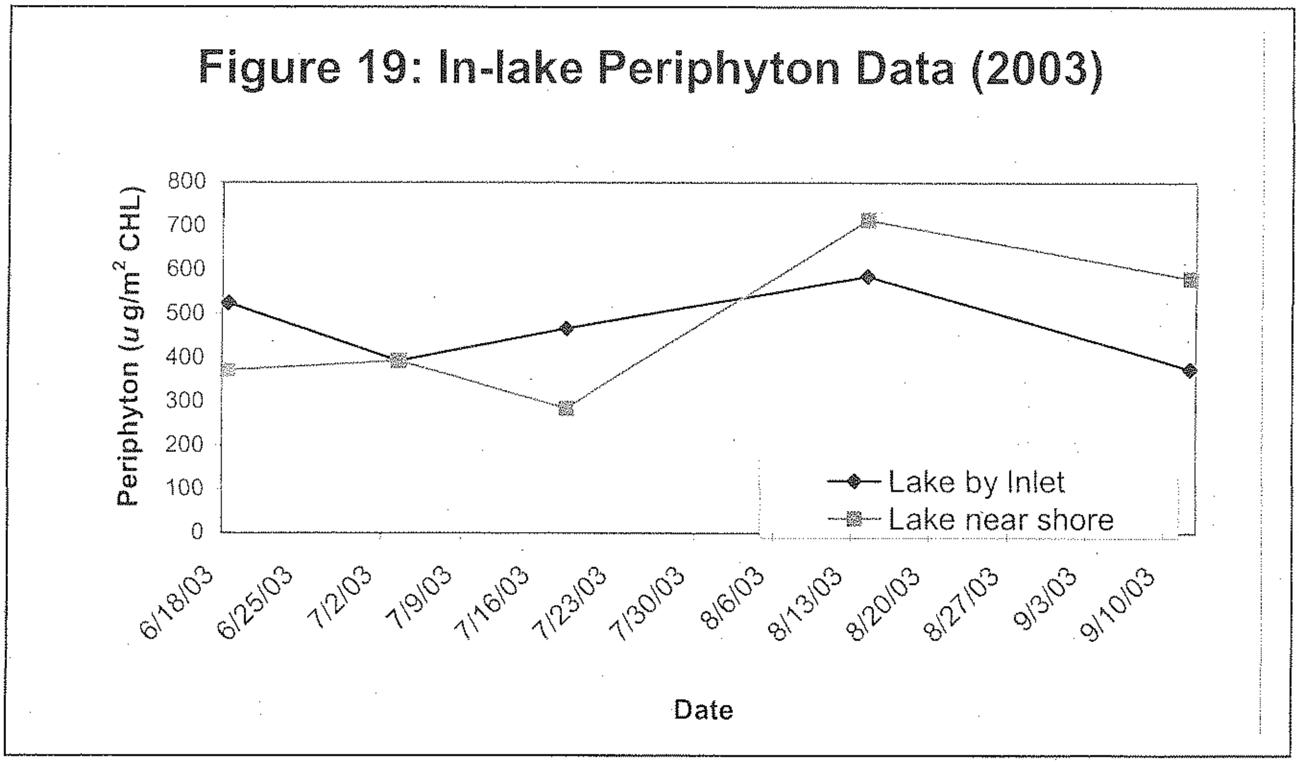


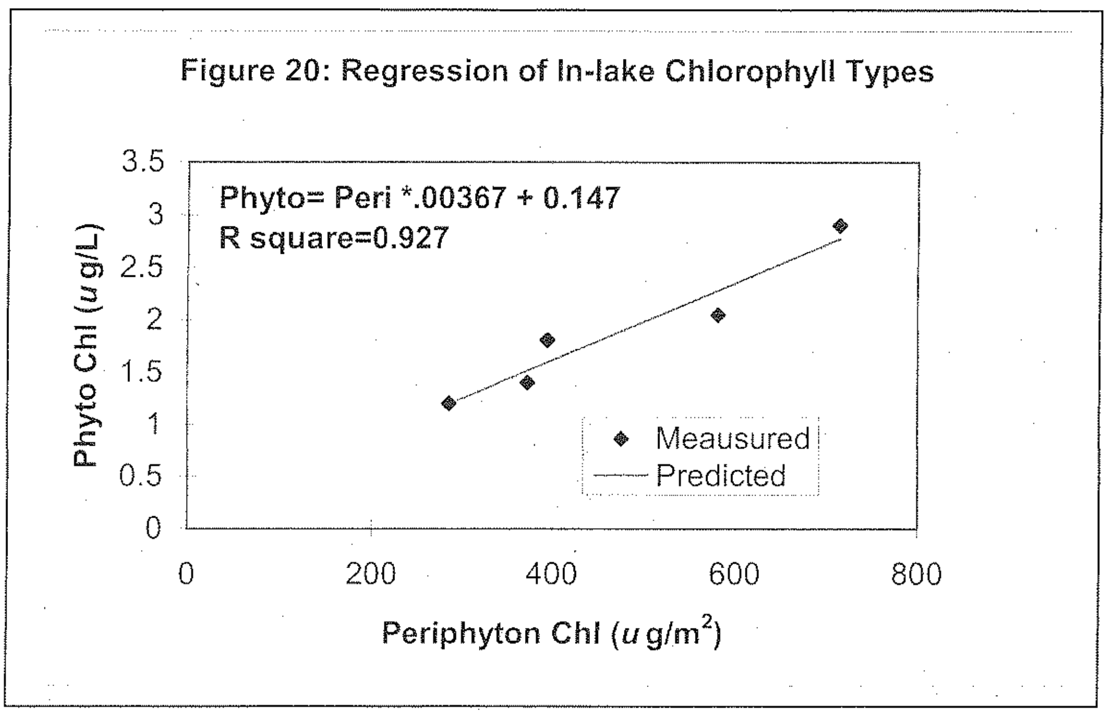
Task III: Chocorua River Wetland and Lake Periphyton Analysis Summary

Periphyton sampler devices were placed along the upper Chocorua River sampling stations within the wetlands studied to try to better understand the possible mechanisms of nutrient assimilation and to also investigate the potential of using an artificial substrate sampler to integrate nutrient levels and nutrient loading over time. These samplers consisted of a 4 by 6 inch block of Styrofoam attached to a brick anchor that was positioned in the flowing stream face up. Also attached was an Onset Corporation data logger that monitored temperature and light conditions every 15 minutes, sealed in a clear submersible case. Samplers for in-lake periphyton sampling were made of similar materials but were larger (3 foot diameter hexagon shaped) and attached to an anchoring frame that allowed for suspension at about 1.5 meter depth. While high taxonomic detail of the periphyton species are well beyond the scope of this work, random samples of some of the samplers indicate that the major species found included *Odegonium, Mougeotia, Zygnema* and *Rhizoclonium* species as the dominant green algae. The dominant diatom species was *Navicula* sp. And occasionally the blue green bacteria *Anabeana sp* was evident in very high numbers.

In-Lake Periphyton Results

The in-lake Periphyton results showed relatively little variation ranging from approximately 300 *ug*/m^2 Chlorophyll to a little over 700 *ug*/m^2 (Figure 19). The periphyton values documented in this study are very low and indicative of an oligotrophic (pristine) system when compared to existing regional studies of stream and lake periphyton samples. The site closest to the Chocorua River Inlet area showed slightly higher biomass early in the season and then decreased to lower levels, relative to the second site which was located just beyond the littoral zone of a more embayed lake area. When compared to open water phytoplankton chlorophyll levels sampled by water filtration from those same sites, the periphyton results followed the phytoplankton results fairly well. The near shore-site periphyton chlorophyll were a good indicator of in-lake phytoplankton biomass as there was a significant correlation between the periphyton and the whole water chlorophyll data (Figure 20). This may suggest that in-lake periphyton samplers may be useful to detect very small differences in productivity given the wider range of values that result with the samplers. A similar correlation between the inlet area sampler did not exist, possibly indicating that the location of that sampler within weed beds or its position close to the flow of the inlet caused more interferences. This was suggested in the analysis of the data logger output as the inlet site had much higher variations in temperature and light throughout the incubations. No significant correlations could be made for either sampler with the measured in-lake total phosphorus levels.





Stream/Wetland Periphyton Results

We learned that the lower wetland complexes in the northern Chocorua River are providing for nutrient loading assimilation as discussed previously in this report. The question we wanted to address with the periphyton samplers was whether the periphyton biomass was related to this assimilation process or whether the periphyton biomass correlates with nutrient levels directly. Figures 21 through 25 graphically display the periphyton biomass results for each of the experimental incubations. On occasions of high flows, some of the samplers were disturbed individually while the heavy storm period in mid to late August created much havoc and resulted in a discontinutity in the data collection for that period. Missing samplers were replaced prior to the August 29-September 11 sampling period to facilitate the collection of data at all sampling locations.

Figure 21: Periphyton Growth
May 29 - June 18, 2003

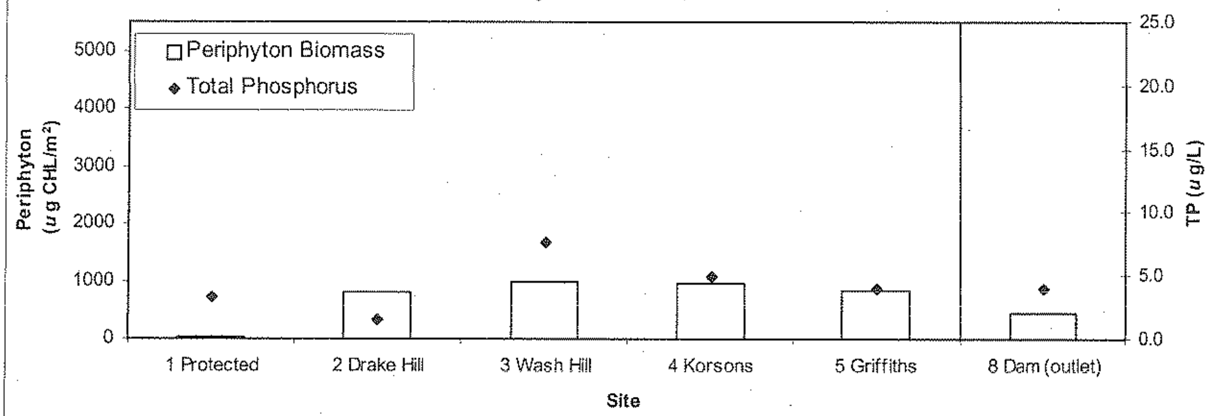


Figure 22: Periphyton Growth
June 18 - July 3, 2003

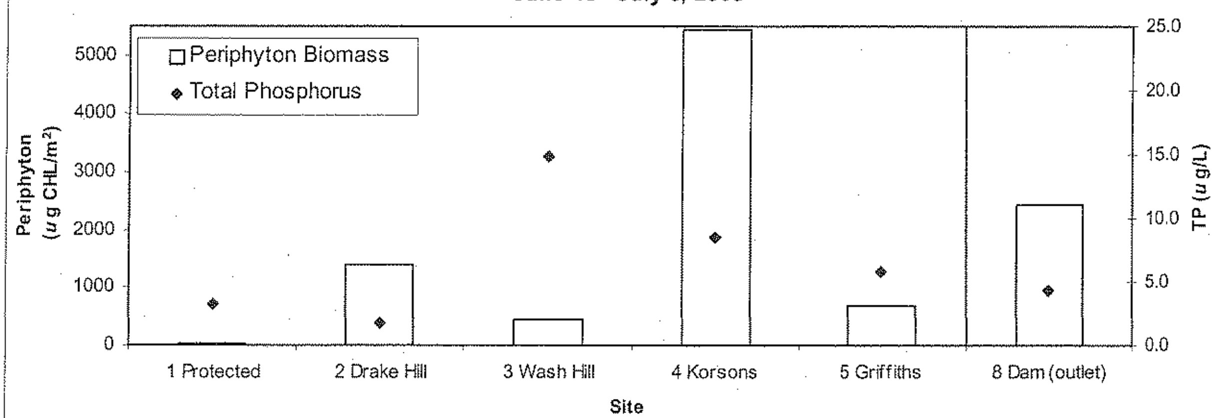


Figure 23: Periphyton Growth
July 3 - July 18, 2003

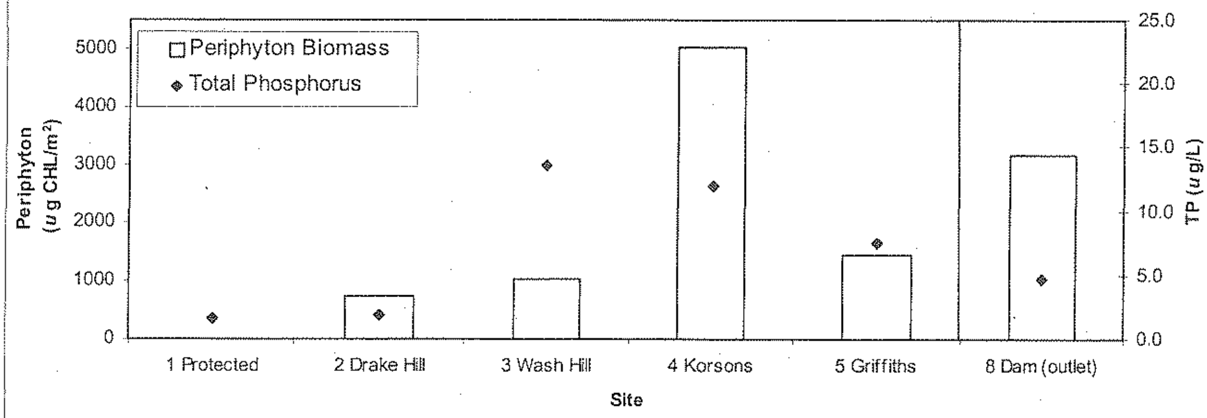


Figure 24: Periphyton Growth
July 18 - August 14, 2003

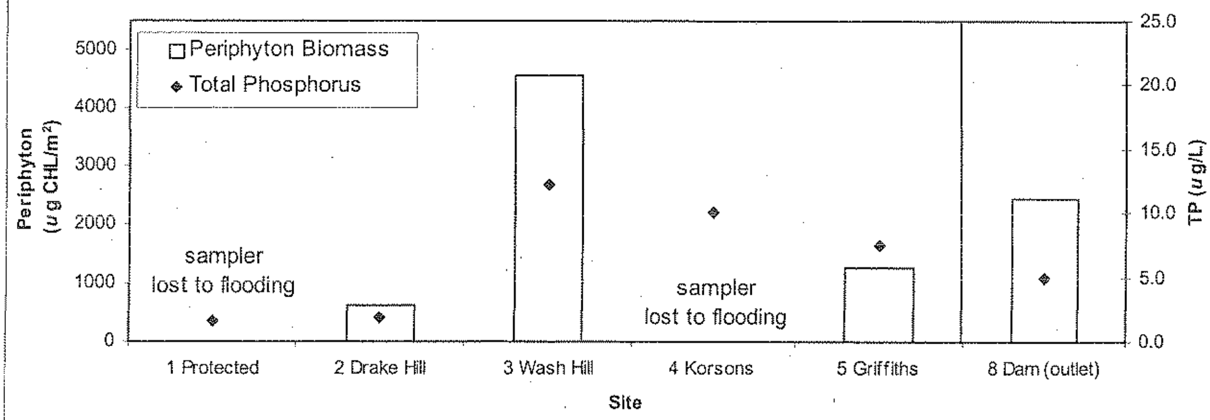
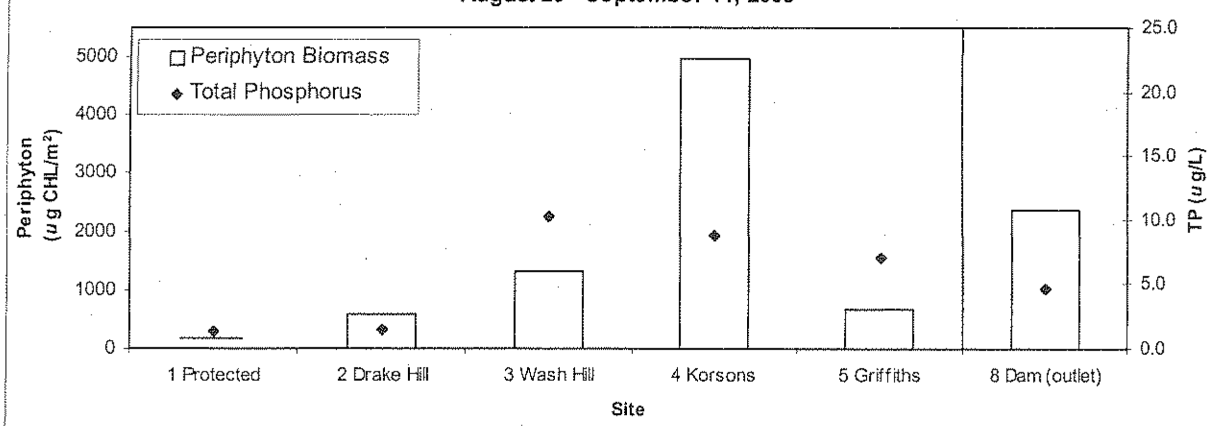


Figure 25: Periphyton Growth
August 29 - September 11, 2003



Compared to the only known published study on regional periphyton in natural streams (New Hampshire and Massachusetts), all results reported in this study are indicative of lower productivity levels. It should also be noted that in addition to the periphyton, many of the sites, especially the Griffiths and Korson's wetland complexes, had diverse submergent vascular plants, mosses and emergent plants.

Periphyton growth started slowly, peaked in mid-summer, and persisted into the fall. Minimal growth occurred at the northernmost ("Protected") site throughout the study period. The Drake Hill Road site had low biomass throughout the season with a slight peak in early in the summer. This was contrary to previous years when much nuisance growth was apparent under dryer low-flow conditions. During most of the incubation periods, the Washington Hill site was characterized by low stream velocities, but high discharge, that is associated with the channel morphology of the sampling location. The deep pooling of highly colored waters did not allow much periphyton growth except during the high flow period in late July and early August. The light data indicate the Washington Hill site was characterized by the lowest light levels of any of the sampling locations and suggest shading might have limited periphyton growth.

The Korson's site had the highest average periphyton biomass of all sites monitored. It seems that during base and low-flow conditions, the periphyton acted in part to assimilate the nutrient loading. Following the flushing of periphyton and other growing matter out of the wetlands, due to the high flow events, nutrient loading increased. The Griffiths site always had reduced periphyton levels, relative to the corresponding periphyton concentrations documented at the Korson's site. Due to additional tributary inflows from the Stony Brook watershed, early season temperatures documented at the Griffiths site were significantly cooler than the temperature at the Drake Hill, Washington Hill and Korsons sites which might account for less periphyton growth. However, the reduced periphyton growth at the Griffiths site is most likely due to the scrub shrub, emergent and braided wetland areas that act to assimilate the majority of the nutrient load.

No significant correlations between integrated nutrient levels, or nutrient loadings, and periphyton biomass were found. The best regressions indicated that only about 20 percent of the variation in periphyton was attributed to nutrient loadings. Accounting for light and temperature variations between sites (if and when they existed) did not improve the relationships significantly. Perhaps the much higher flow conditions experienced during parts of the study period affected any chance of teasing out these relationships.

There is some indication that the TP levels at the preceding (upstream) sites may influence the periphyton biomass of the downstream sites. (see TP patterns in Figures 21 through 25). However, additional site bracketings would be required to develop a more extensive dataset to prove this observation. Intuitively it follows that a higher TP level from a site upstream of a periphyton sampler would produce a related yield of periphyton biomass, and an associated decrease in the TP concentration, as the water passed through the wetland.

For comparative purposes, Figures 21 through 25 include the lake outlet periphyton results. Except for the early spring sampling date, the periphyton biomass documented at the in-lake sampler (Little Chocorua Lake) was more comparable to the Chocorua River biomass than the Lake Chocorua biomass. This was not very surprising since the sampler was positioned just before the dam, in shallow lake waters, that flowed throughout the sampling period. Neither the periphyton biomass nor the total phosphorus concentrations fluctuated much after the initial spring incubation period which suggests the expected moderating effect of the lake through periods of fluctuating phosphorus loadings.

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1.0 Project Organization and Responsibility

The Chocorua Watershed Project Phase II, post Best Management Practice (BMP) effectiveness assessment, is a cooperative effort among local, state and federal groups/agencies. The two primary partners are University of New Hampshire Cooperative Extension (UNH CE) and the Chocorua Lake Association (CLA). The project manager, Jeff Schloss, was responsible for the final data review, interpretation of the water quality data and writing the final project report. The Quality Assurance (QA) manager, Robert Craycraft, trained the proper sample collection and watershed monitoring techniques to the CLA volunteer monitors. Robert Craycraft and Jeffrey Schloss were also responsible for training Center for Freshwater Biology (CFB) field team staff applicable sample collection and water quality monitoring techniques required as outlined in this proposal. Fixed lab samples for this project were analyzed at the CFB laboratory. The end data users may include local decision makers, lake, land and watershed associations, agency staff, advisory boards, educators and their students, researchers, conservation organizations, service groups, private consultants and interested citizens.

A pre-existing Chocorua Lake Project Team was briefed of study findings will be consulted for future monitoring and mitigation efforts. The Chocorua Lake Project Team is being facilitated through the North County Resource and Conservation District and includes members representing the CLA, the Lakes Region Planning Commission, the New Hampshire Department of Environmental Services (NHDES), the New Hampshire Lakes Lay Monitoring Program, the Natural Resource Conservation Service (NRCS), the NH Department of Transportation (DOT), the Chocorua Lake Conservation Foundation, the Carroll County Conservation District, the Green Mountain Conservation Group and the Tamworth Selectmen (Table 5). The Lakes Lay Monitoring Program (LLMP) utilized its existing volunteer network to contribute to the proposed monitoring effort.

This project was funded by a US EPA Clean Water Act, Section 319, grant through the New Hampshire Department of Environmental Services.

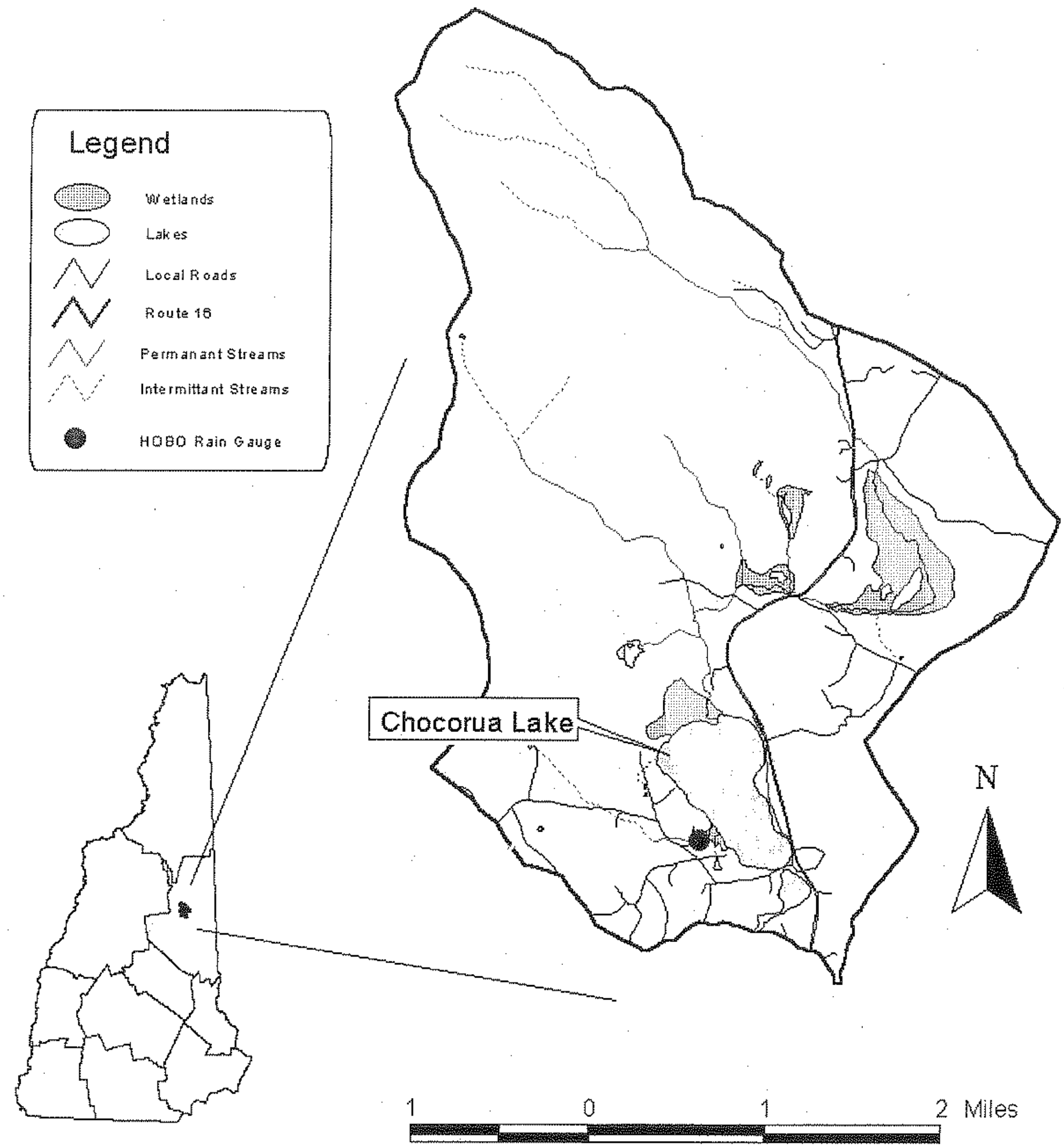
Table 5. Chocorua Lake Project Team Members

Name	Organization Represented
Robert Craycraft	University of New Hampshire Cooperative Extension
Ken Kyle	NH Department of Transportation
Mark Morrill	NH Department of Transportation
David Little	Chocorua Lake Foundation
Neeley Lanou	Chocorua Lake Foundation
Jeffrey Schloss	UNHCE and UNH Center for Freshwater Biology
Joan Richardson	Natural Resource Conservation Service
Rick Ellesmore	Natural Resource Conservation Service
Dwight Baldwin	Chocorua Lake Association
Toby Page	Chocorua Lake Assoication
John Roberts	Tamworth Selectman
Rick Demark	North Country Resource and Conservation District
Eric Williams	NH Department of Environmental Services
Peter Pohl	Carrol County Cooperative Extension
Brianne Fellows	Americorp Member
Blair Folts	Green Mountain Conservation Group

1.1 Problem Definition/Site History and Background

Phase II of the Chocorua Watershed Project focuses on the Chocorua Lake Watershed (Figure 26), Tamworth, New Hampshire where ongoing remediation efforts are directed at reducing Non Point Source (NPS) pollution impacts on Chocorua Lake. A watershed nutrient/water budget (conducted 1996-1997; reported: Schloss 2000), conducted by the University of New Hampshire Center for Freshwater Biology, indicated a disproportionate concentration of phosphorus entered Chocorua Lake from the Route 16 subwatershed; the Route 16 subwatershed constituted only 5% of the Chocorua watershed flow but accounted for 15% of the annual phosphorus load. On an areal basis (per unit area) the Route 16 subwatershed had more than 3 times the loading than the western drainage (largest land area) and over 2 times the loading of the eastern drainage. The construction of berms and swales, as well as, riparian plantings have been completed between the northeastern segment of Chocorua Lake and Route 16 that runs adjacent to the lake.

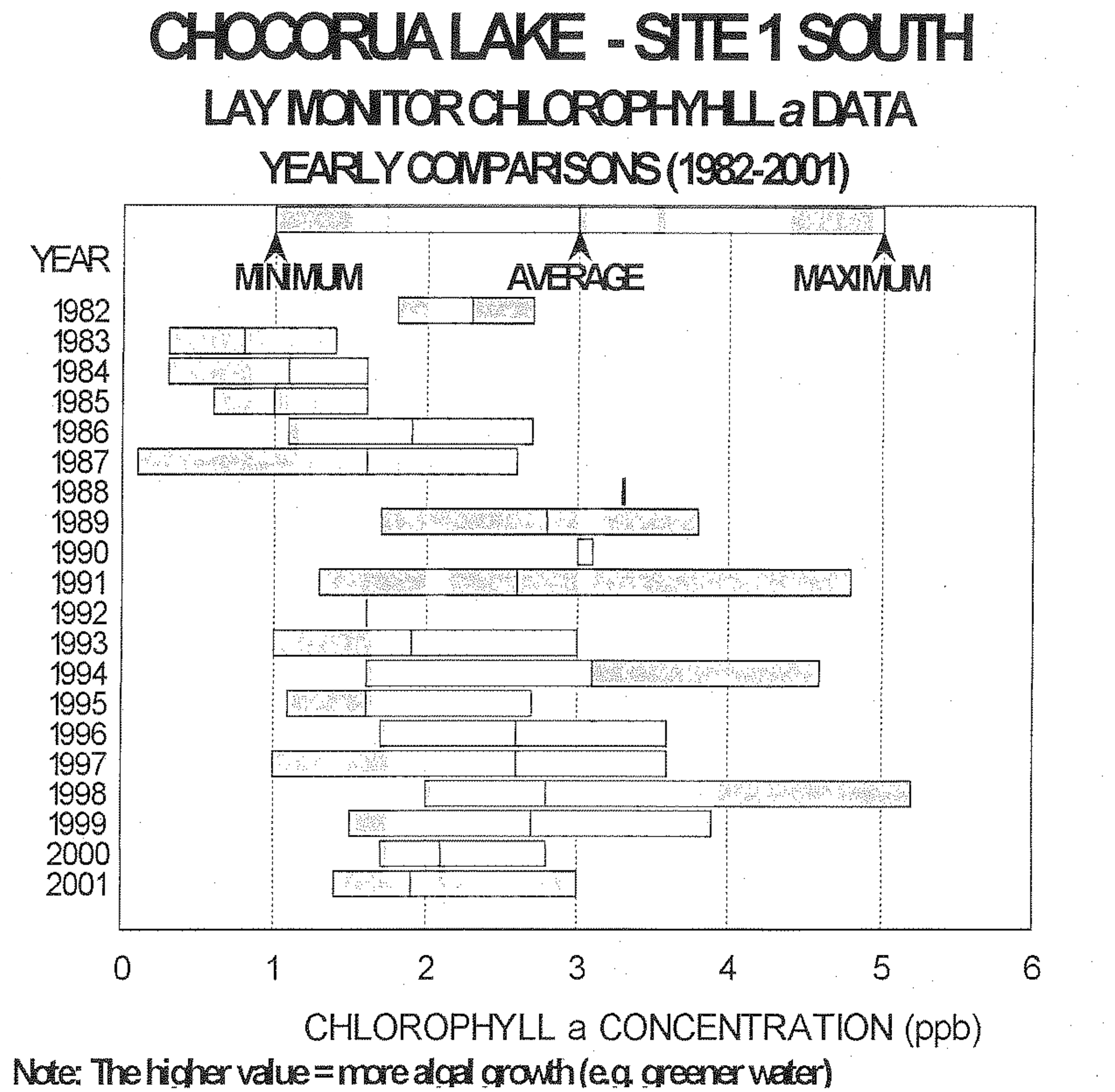
Figure 26. Chocorua Lake Watershed Carroll County, Tamworth New Hampshire



Chocorua Lake, Tamworth New Hampshire, is located in the Ossipee Lake watershed that contains New Hampshire's largest stratified drift aquifer. The Chocorua Lake watershed is predominantly forested, with riparian cover along the northern, western and southern sections of Chocorua Lake. The Rt. 16 travel corridor, a major transport route to the White Mountains National Forest and numerous ski areas, runs adjacent to the eastern section of Chocorua Lake. The Rt. 16 travel corridor is characterized by a significant reduction in riparian vegetation to the east and has been identified as a major source of NPS pollution that enters Chocorua Lake (Schloss, 2000).

Water quality data collected between 1982 and 2001 exhibit a general increase in algal growth over the 18 year span (Figure 27). The increase in algal growth, through 1995, culminated in heightened awareness of potential water quality problems. This heightened awareness prompted an in-depth water/nutrient budget of the Chocorua Lake watershed that was conducted between May 1996 and July 1997 by the LLMP in conjunction with CLA. The Chocorua Lake water/nutrient budget entailed the collection of weekly stream discharge and total phosphorus samples from the

Figure 27. Chocorua Lake: Annual chlorophyll *a* trends.



permanent stream inlets and the Chocorua Lake Outlet. A series of intermittent stream culverts, adjacent to Rt. 16, were also sampled during the period of spring thaw and during/following heavy storm events (Figures 28 and 29). The study results indicated that a disproportionate amount of phosphorus loading occurred in the Rt 16 subwatershed (on a per unit area basis); the Rt 16 drainage contributed more than twice the phosphorus load of the Chocorua River and over three times the phosphorus load of the western drainage (Figure 30).

Water quality data collected by the CLA and LLMP clearly indicated NPS pollutant inputs were having an adverse affect on Chocorua Lake. The Chocorua Lake Project Team formed in 1997, with the goal of identifying and mitigating water quality problems within the watershed. Following numerous meetings and a period of consensus building, several erosion problems along Rt 16 were prioritized and Phase I grant monies were obtained to institute BMPs that included culvert modifications, the construction of berms, swales and the lining of culverts with rip-rap. Phase II of this project was developed to answer four primary questions:

- What is the effectiveness of BMPs, installed adjacent to Rt. 16, at attenuating nutrients and total suspended solids in a series of drainage culverts adjacent to Rt 16?
- What is the effectiveness of a series of wetland complexes along the Chocorua River at attenuating phosphorus prior to reaching the Chocorua Lake? Can this phosphorus attenuation be detected through the use of periphyton monitoring?
- Has the Chocorua Lake water quality improved since the implementation of the Rt. 16 BMPS?

The Rt 16 BMP effectiveness was assessed through a series of upstream/downstream sampling sites to discern the changes in total suspended solids, total phosphorus, total nitrogen, specific conductivity, temperature and turbidity as water flows through the BMP treatment areas. The BMP effectiveness study consisted of a series of paired watersheds that were used to evaluate the effectiveness of the BMPs relative to locations where no BMPs had been implemented. Measured parameters included soluble reactive phosphorus, total phosphorus, total nitrogen, total suspended solids, specific conductivity, temperature, turbidity and stream discharge.

The Chocorua Lake water/phosphorus budget demonstrated that a series of wetland complexes along the northern, Chocorua River, tributary inlet serve to attenuate nutrients before reaching Chocorua Lake. These natural detention basins provide the vital function of purifying the water and minimizing the impacts of future land use change, thus minimizing the rate of eutrophication. Data generated through this study are intended to highlight the importance of these natural detention basins in hopes that future land management techniques will protect these valuable resources.

The Chocorua River sampling regime also included a series of upstream/downstream artificial periphyton substrates that integrated the long-term nutrient load into Chocorua Lake and were used to assess how well the wetland complexes attenuate nutrients. These periphyton samplers served as surrogates for the nutrient loading that occurs between the spring and fall months since our resources did not facilitate the deployment of nutrient autosamplers nor the analysis of arguably thousands of nutrient samples that would be required to determine the nutrient attenuation as water passes through the series of wetlands. However, we concurrently collected soluble reactive phosphorus, total phosphorus, total nitrogen, turbidity and temperature measurements to add to our baseline physio/chemical data.

Figure 29: Route 16 Post BMP Culvert Monitoring (South).

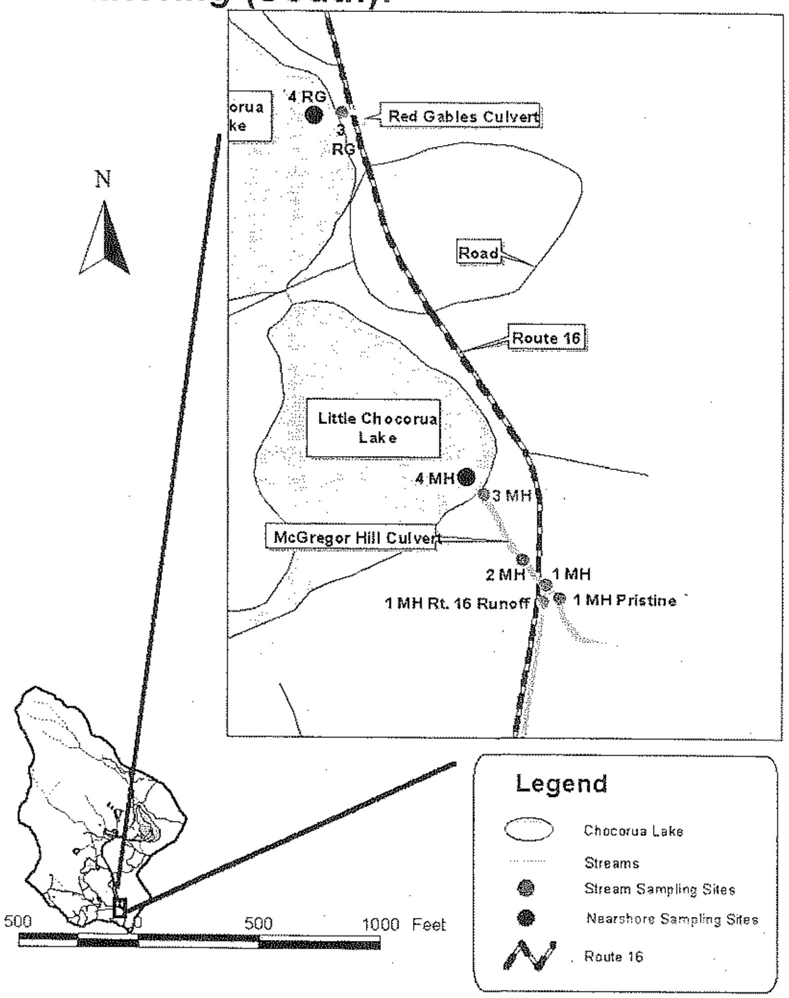
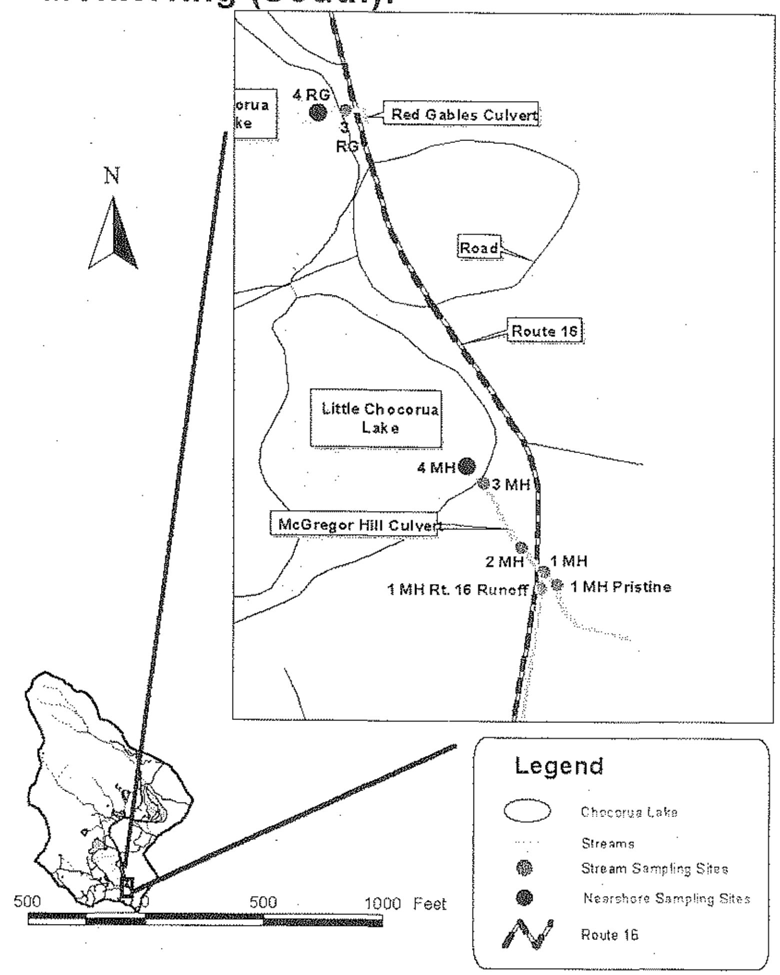
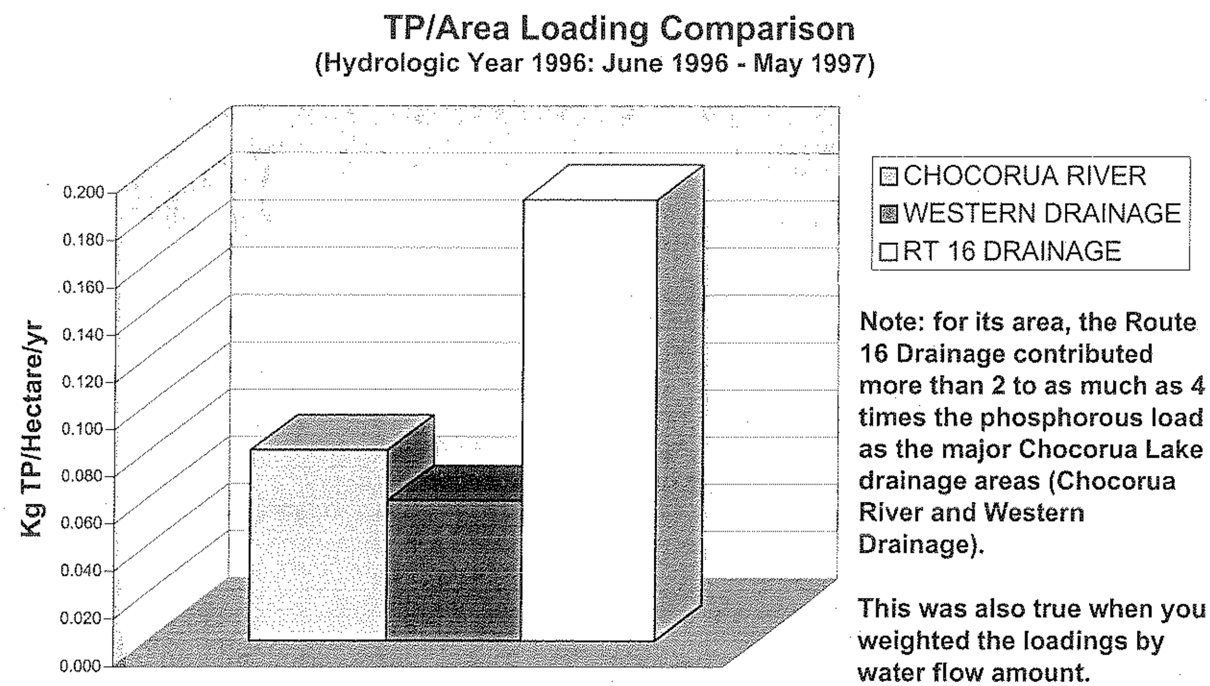


Figure 29: Route 16 Post BMP Culvert Monitoring (South).



In-lake total phosphorus and Secchi Disk transparency data were collected at a deep centrally located sampling location, a sampling location at the mouth of the Chocorua River and a sampling location at the outlet of Chocorua Lake to assess the lake response to nutrient loading. The LLMP has a long-term record of Secchi Disk transparency and total phosphorus data dating back to 1982 that will be used to assess the Lake's response to the implemented BMPs.

Figure 30. Chocorua Lake Phosphorus Loading per unit area



2.0 Project Description and Schedule

2.1 Project Overview

The Chocorua Watershed Project Phase II was designed to complete a series of objectives that were identified at previous Chocorua Lake Project Team meetings. The objectives were:

1) To document the success of our collaboration as exemplified in the effectiveness of the implemented BMPs adjacent to Route 16.
2) To provide information that could be used/transferred to benefit non-point source pollution reduction efforts throughout the state and region.
3) To evaluate the impacts/benefits of the wetland complexes and peripheral wetlands in the watershed.
4) To attempt to mitigate existing threats and minimize additional threats to the water quality in the watershed.
5) To better understand and define future threats within the Chocorua Watershed.

While these objectives represent separate efforts per se, they all are related to, and compliment, each other in providing a greater understanding of the watershed system as a management unit. While beyond the scope of this project, the objectives outlined above will ultimately facilitate the development of a Lake Diagnostic Model that will enable us to predict the lake response to phosphorus loading decreases and increases.

The Chocorua Watershed Project Phase II objectives were accomplished by implementing three sampling tasks:

2.1.1 Task I- Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts.

Rationale: At the core of the CWPP QAPP is the need to continue the follow-up, post-BMP monitoring that will document the effectiveness of the management practices put in place to reduce the sediment and phosphorus load into Chocorua Lake. We set up a series of sampling stations in each culvert that tracked the nitrogen, phosphorus and TSS levels as the water flows from a forested site, through an impacted stretch of the culvert and into Chocorua Lake (Figures 28 and 29). The sampling design allowed us to follow storm flow through the BMP treatment areas to see what pollutant reductions took place.

Sampling Tasks: Physical and Chemical water quality samples and measurements were collected during, or immediately following heavy storm events, when the sediment and nutrient loading tends to be most severe. An attempt was made to collect the water sample during the most intense period of each storm event.

Analysis Tasks: Temperature and Specific Conductivity measurements were measured in-situ throughout the monitoring period while water samples were collected and analyzed in the laboratory for nutrients and total suspended solids. Discharge measurements were calculated based on the stream channel dimensions and the concurrent streamflow measurements that were collected in each of the six culverts during each sampling event. Discharge calculations are based on standard hydrological calculations (width * depth * velocity). Laboratory analyses were performed in the CFB laboratory and included Total Phosphorus (TP) analysis, through persulfate digestion, Total Nitrogen (TN), through second derivative spectroscopy, Total Suspended Solids (TSS) and Turbidity.

2.1.2 Task II - Deep Lake and Major Tributary Sampling.

Rationale: Post-BMP total phosphorus and Secchi Disk data were collected in Chocorua Lake and were compared to the Pre-BMP phosphorus and Secchi Disk transparency data to determine whether or not the in-lake phosphorus concentrations improved (i.e. lower values) since the BMPs were implemented in 1999.

Sampling Tasks: Bi-weekly water quality samples were collected at three sampling locations in Chocorua Lake to track the seasonal phosphorus concentrations at the major tributary inlet (Site 1P), at a centrally located deep reference location (Site 2P) and near the Chocorua Lake outlet (Site 3P) as depicted in Figure 31. Supplemental Secchi Disk transparency measurements were limited to the deep centrally located sampling station (Site 2P) to discern the seasonal Secchi Disk transparency trends and to determine the seasonal average water transparency. The Task II water quality data were collected following the period of ice-out and continued through the period of fall overturn that typically occurred in mid-September at the Chocorua Lake deep reference location.

Analysis Tasks: Secchi Disk transparency measurements were collected by the CLA volunteers at the deep Chocorua Lake sampling location (Site 2P) on each sampling date. No Secchi Disk transparency data were collected at the tributary inlet or the lake outlet due to the shallowness of the sites. TP data were collected by the CLA volunteers at each of the three sampling stations during the entire study period.

2.1.3 Task III- Integrated Nutrient Sampling of Pre and Post Wetland Impacts.

Rationale: A series of periphyton (attached algae) samplers served to assess the effectiveness of a series of natural wetlands at attenuating nutrients before reaching Chocorua Lake. Samples collected upstream and downstream of a series of wetland complexes located along the Chocorua River, as well as, samples collected in Chocorua Lake served to track changes in the nutrient loading among sampling locations (Figure 32). The periphyton samples integrated the nutrient load over relatively long (i.e. two week) time periods and will reflect short-term nutrient inputs that might be missed during a more traditional nutrient sampling study during which discrete (i.e. weekly/bi-weekly) samples are collected. Soluble reactive phosphorus (SRP) samples, absent from Tasks I & II, were included in Task III to best assess the amount of phosphorus available to promote periphyton growth. Considering the Chocorua River is a lotic system, it was important to collect the SRP samples that best reflected the phosphorus available for periphyton growth at the various sampling sites. Total phosphorus samples were collected at the Task III sampling sites since the phosphorus is ultimately deposited into lentic systems, wetland complexes and ultimately Chocorua Lake, where the total phosphorus will become available to photosynthetic organisms through chemical conversions associated with the phosphorus cycle. The relationship between TP and in-lake phytoplankton growth has been well established in the scientific literature.

Sampling Tasks: Physical and Chemical and Biological water quality samples and measurements were collected during each sampling event. Light, temperature and humidity data were downloaded from the HOBO field meters during each sampling trip. The Task III data were collected on a bi-weekly basis to facilitate sufficient periphyton growth between successive sampling trips.

Analysis Tasks: Temperature and Specific Conductivity measurements were measured in-situ throughout the monitoring period while water samples were collected and analyzed in the laboratory for nutrients and total suspended solids. Discharge measurements were calculated based on the stream channel dimensions and the concurrent streamflow measurements that were collected in each of the six culverts during each sampling event. Discharge calculations are based on standard hydrological calculations (width * depth * velocity). Laboratory analyses were performed in the CFB laboratory and included TP analysis, Soluble Reactive Phosphorus (SRP) analysis, TN analysis, Turbidity analysis and chlorophyll *a* via spectrophotometric analysis.

Figure 31: In-Lake and Major Tributary Sampling Sites.

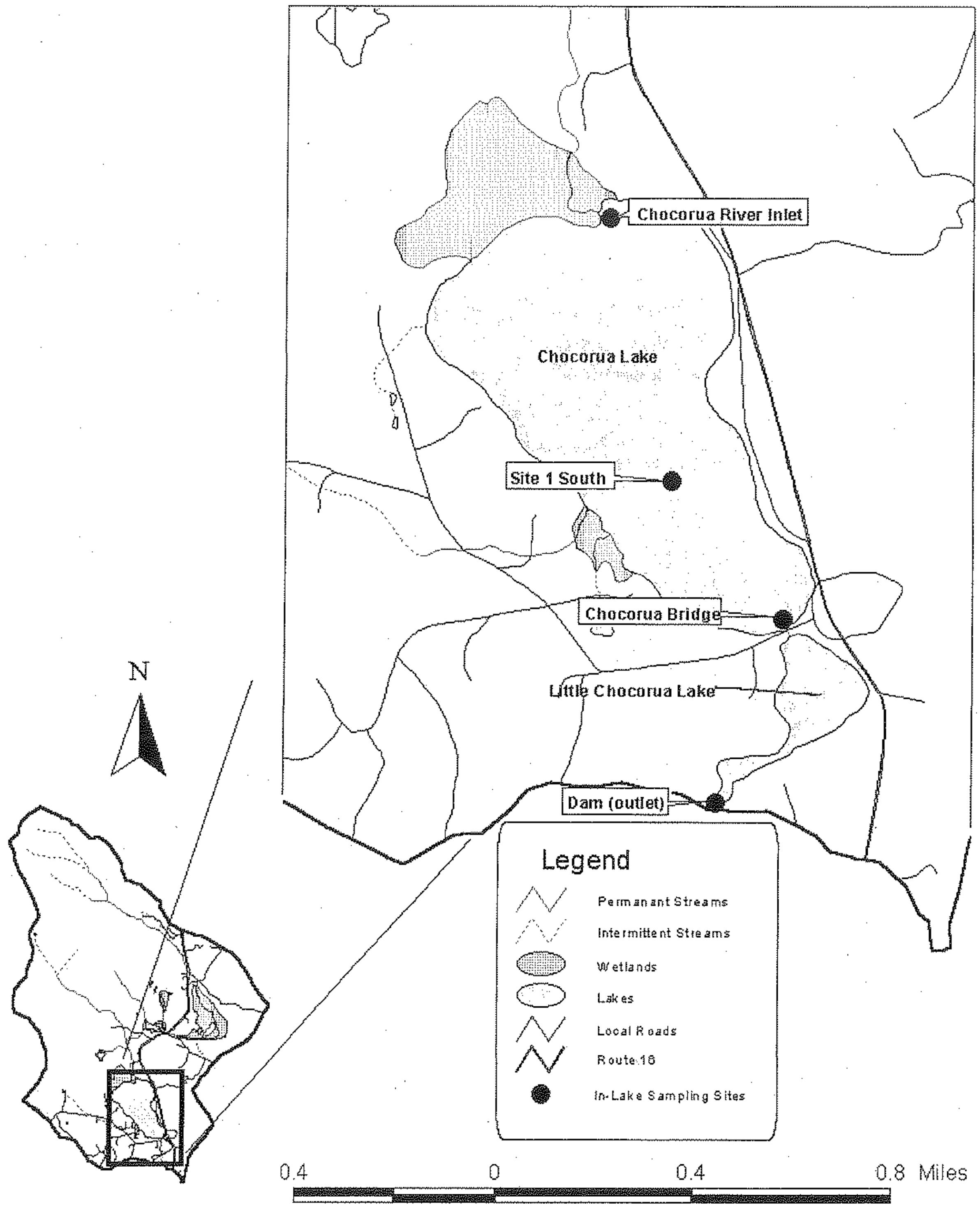
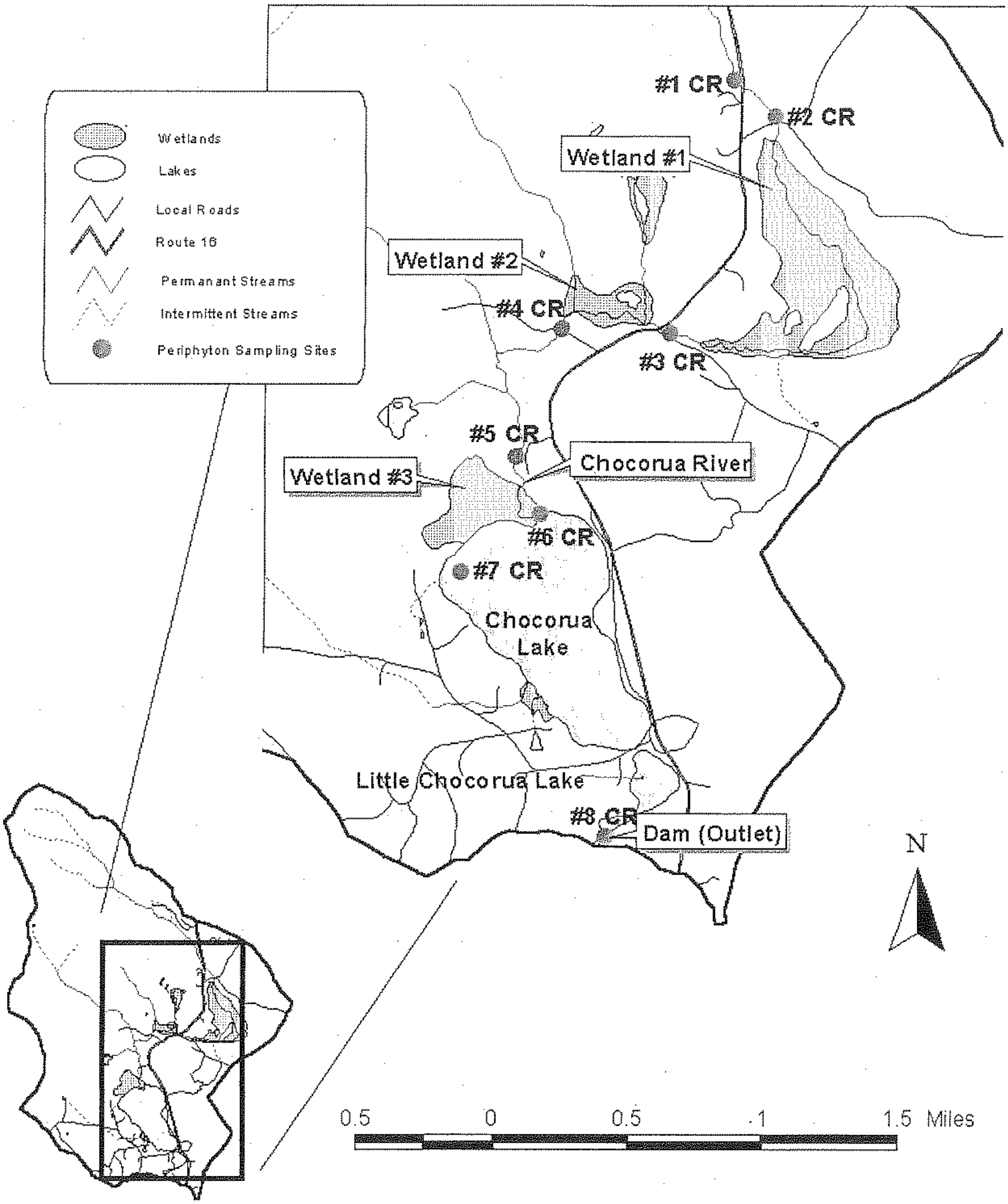


Figure 32: Periphyton Sampling Locations.



3.0 Project Quality Objectives and Measurement Performance Criteria

3.1 Project Quality Objectives

The data generated through this study were primarily used to determine the effectiveness of BMPs along Rt 16 to determine the ability of wetlands to attenuate nutrients, and to discern trends and locate actual or potential NPS pollution threats within the watershed. In addition, the data will assist in the development of watershed protection recommendations. No direct enforcement or legal actions are planned to be taken from any of the sampling. If any suspect conditions or violations are indicated by the CFB data, we will alert the health officers of the towns and the New Hampshire Department of Environmental Services Water Division (the proper authorities for code enforcement and legal actions).

Data were collected using consistent sampling protocols and the laboratory samples included a minimum of 10% replicate and 10% blank samples. Nutrient concentrations documented by previous CFB studies indicate low baseline phosphorus concentrations (<5 ug/L) in our reference sampling locations. To maximize the reliability of our nutrient data, 100% of TP, TN and soluble reactive phosphate samples were analyzed as laboratory replicates.

3.2 Measurement Performance Criteria

Precision is the degree of agreement between/among repeated measurements that are collected simultaneously at the same field sampling location. For the purpose of this study will be assessed as the relative percent difference (RPD) between replicate samples using the equation:

$$\mathrm{RPD} = \frac{(x_1 - x_2)}{(x_1 + x_2)/2} \times 100$$

At least one field replicate was collected during each sampling event and a minimum of 5% of the field samples were collected in replicate. When multiple field sampling teams collected samples during a field visit, each team collected at least one field replicate. The desired field precision data are reported in table 6 while the RPD of laboratory replicates were set at 10% for the TP and SRP samples. Laboratory precision for TN samples will be set at 15% for concentrations below 500 *u*g/L and at 10% for concentrations at or above 500 *u*g/L.

Accuracy/Bias is an indicator of measurement confidence. Accuracy was measured by the analysis of spiked laboratory samples. A sample is divided into two portions (aliquots). A known amount of

Table 6. Measurement Performance Criteria For Surface Water Samples in a water matrix.

Parameter	Meas. Range	Precision (field)	Accuracy	Reporting Limit
Total Phosphorus	3.0 - 200.0 *u*g/L	+/- 15%	90 - 110%	2 *u*g/L
Soluble Reactive Phos.	2.0 - 30.0 *u*g/L	+/- 1 ug/L; +/- 10%[1]	90 - 110%	1 *u*g/L
Total Nitrogen	100 - 1000 *u*g/L	+/- 15%	90 - 110%	100 *u*g/L
Turbidity	0.2 - 100.0 NTU	+/- 15%	-----	0.20 NTU
Temperature	0.0 - 30.0°C	+/- 0.2 °C	-----	0.1°C
Specific Conductivity	10.0 - 2000 *u*S/cm	+/- 5%	-----	10 *u*S/cm
Total Suspended Solids	2.0 - 100.0 mg/L	+/- 15%	-----	2.0 mg/L
Chlorophyll *a*	0.5 - 10.0 mg/m^2	+/- 20%	-----	0.2 mg/m^2

[1] Precision will be +/- 1 *ug*/L for SRP values below 10 *ug*/L and +/- 10% for SRP values at or above 10 *ug*/L.

standard is added "spiked" to one aliquot. Both aliquots are then analyzed and the amount of the spiked material recovered is compared to the amount added using the following equation:

$$\%\ \text{Accuracy/Bias} = \frac{\text{SpikedSampleConc.} - \text{UnspikedSampleConc.}}{\text{Spiked Conc. Added}} \times 100$$

Spiked TP, TN and SRP samples will be analyzed at a frequency of 5% or one per analytical batch, whichever is more frequent.

Quantitation Limits (Reporting Limits) – The quantitation limit is the lowest value which a laboratory can quantitatively report with confidence. The analytical method, analytical/achievable method detection limit, and the analytical/achievable laboratory quantitation limits for this project are summarized in Table 7.

Representativeness is a qualitative term that describes the extend to which a sampling design adequately reflects the environmental conditions of a site. Sampling locations outlined in this study were chosen that would best reflect the nutrient and sediment loading into Chocorua Lake and that would also serve to assess the effectiveness of the implemented BMPs around the lake and to monitor nutrient attenuation function of the surrounding wetlands. Site locations and rationale were previously discussed under the site and methodological summaries.

Comparability among samples was achieved by maintaining consistency with SOPs, sampling locations and sampling methods. Samples were collected at the same, specified, locations throughout the study and all samples were processed within the specified holding times. Many of the current sampling locations correspond to historical sampling locations that allowed data comparisons between the data collected during this study and the historical data collected by the University of New Hampshire Lakes Lay Monitoring Program.

Completeness. The completeness of the database is a critical aspect of data quality and data usefulness. These data were used to assess the effectiveness of implemented BMPs and the ability of wetland complexes to attenuate nutrients. The study will attempt to characterize a minimum of three intense storm events (> .75 inches) as well as up to seven additional storm events. However, given the inherent difficulty of collecting water samples at specific points during a storm event, there will likely be storms for which incomplete data are collected. The intermittent nature of the streams might also result in the collection of only partial data during a given storm event.

4.0 Sampling Process Design (Experimental Design)

Table 7. Surface Water Target Analytes and Detection Limits

Analyte	Analytical method (See Appendix A for SOP Reference	Analytical/Achievable Method Detection Limit	Analytical/Achievable Laboratory Quantitation Limit
Total Phosphorus	Std. Meth. 4500-P E.	0.78 *u* g/L	2.0 *u* g/L
Soluble Reactive Phosphorus	Std. Meth. 4500-P.E.	0.27 *u* g/L	1.0 *u* g/L
Total Nitrogen	* Primary literature	35.8 *u* g/L	100 *u* g/L
Total Suspended Solids	Std. Meth. 2540 D.	0.3 mg/L	2 mg/L
Temperature	Std. Meth. 2550 B.	-----	-----
Conductivity	Std. Meth. 2510 B.	0.5 *u* S	10 *u* S
Turbidity	USEPA 180.1	0.05 NTU	0.20 NTU
Chlorophyll	Std. Meth. 10200 H.2	0.1 mg/m^2	0.2 mg/m^2

*Total Nitrogen Analyses via second derivative spectroscopy are based on the methods described by Bachman and Canfield (1996) and by Crumpton, W.G (1992). The second derivative spectroscopy method is currently under review and should appear in the 21st edition of Standard Methods. Refer to appendix E for copies of the primary journal articles.

4.1 Sampling Design Rationale

Three sampling tasks were required for this project that collectively increased our understanding of nutrient loading and potential threats within the Chocorua Lake watershed. Each of the three tasks are described below and include specific rationale for the respective tasks while the collective data will ultimately be used in future water quality modeling of Chocorua Lake.

4.1.1 Sampling Task I- Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts

A nested watershed design, a.k.a. an "above-and-below" design was used to evaluate the effectiveness of BMPs that have been designed and implemented along Route 16. These sites represent those areas that have BMPs in place and areas that remained unchanged to serve as "controls". During a pre-conference workshop at the 14^{th} Annual Enhancing the States' Lake Management Programs, Davenport et. al. (April 17, 2001) suggested pre/post watershed studies should optimally include both an upstream/downstream and paired watershed component to the study. The CWPP employed such an approach to best assess the impact of the BMPs by monitoring upstream/downstream of the berms, swales, rip-rap and plunge pools. Paired watersheds controled for the effects of hydrologic variation and account for the natural water quality variations. We collected runoff samples on six sampling dates and occured during and immediately following periods of heavy precipitation. We also compared historical, pre-BMP data, with the 2003 CWPP data to further assess the effectiveness of the implemented BMPs. TP, TN TSS, Turbidity, Conductivity and Temperature data were collected at 24 sampling locations as indicated in Table 8.

Six culverts will be sampled at multiple points, during or immediately following storm events, to assess the effectiveness of the implemented BMPs to attenuate pollutants before the contaminants enter Chocorua Lake. The storm sampling will be limited to precipitation events

Table 8. Sampling Task I Field Sampling Summary.

Analyte	Total no. of sampling locations	Number of runoff events sampled	Total number of samples possible	Total number of samples analyzed	Completeness
Total Phosphorus	24	6	144	115	79.9%
Total Nitrogen	24	6	144	104	72.2%
Total Suspended Solids	24	6	144	110	76.4%
Turbidity	24	6	144	109	75.5%
Conductivity	24	6	144	115	79.9%
Temperature	24	6	144	117	81.3%
Streamflow	6	6	36		NA

during which the rainfall totals a minimum of ½ inch over a 24 hour period while at least two of the storm sampling events be conducted during storm events characterized by ¾ inches of rainfall, considered the threshold for significant overland runoff (Hewlett, 1982), over a 24 hour period. A minimum antecedent dry period of 72 hours will be required between any two successive storm sampling events. Storm event sampling will focus on the spring period of spring melt when the ground is saturated and minimal vegetative cover is available to intercept water and particulate debris. Likewise, emphasis will be placed on storm event sampling that is conducted during wet summer and fall periods where heavy periods of rainfall over the past several days/week have raised the groundwater table and will translate into increased stream-flow. Additional storm event sampling will be conducted during the drier summer months that are generally characterized by a lower water table and reduced groundwater recharge that coincide with increased evapotranspiration rates. Storm events during the dry summer months will be characterized by an increase in the relative contribution of the Rt 16 sheet runoff and will provide some insight into the BMPs' abilities to slow the water flow and attenuate particulate debris when the vegetative cover comes into bloom.

The CFB field team will prepare the appropriate sampling equipment and sampling bottles when large storm fronts have been identified and are predicted for the Town of Tamworth, NH. The storm event sampling will be conducted when the rainfall culminates into overland, channelized, flow in our Task I study culverts. Since sediment runoff was previously identified as the primary means of phosphorus loading along the Rt 16 corridor (Schloss, 2000), our criteria for culvert sampling will be based on the presence of surface flow as opposed to some absolute antecedent rainfall threshold. Intense (i.e. downpours) storm events will be selected over other less intense storm events. Focus will also be placed on long-duration storm events that will saturate the soil and increase the amount of surface water flow.

Ambient precipitation data will be collected within the Chocorua Lake watershed (Figure 19) using a HOBO (model RG2) data logging rain gauge that records ambient rainfall in .01 inch increments. Precipitation data collected at the National Oceanic and Atmospheric Administration, Tamworth 4, climatological sampling station will also be reviewed following the respective storm events to determine whether or not the rainfall exceeded the ½ inch and ¾ inch thresholds. The CFB field team will attempt to collect the water quality data during the period of peak precipitation although data collected anytime during or immediately following the storm event, when the culverts are running, will be deemed acceptable.

The site nomenclature used in this study will consist of the culvert names followed by a numerical value between 1 and 4 as indicated in Table 9 and Figures 21 and 22 (note: the Red Gables culvert only consists of a lower site (#3) and an in-lake site (#4) due to the diffuse runoff that does not become channeled until it reaches Chocorua Lake).

Table 9. Task I Sampling Sites within each culvert and sampling rationale.

Site #	Location	Rationale
1	Forested watershed - upstream of Rt 16	Reference site for the respective culvert
2	3 meters downstream of Rt 16	Impaired site that receives Rt 16 runoff
3	In-stream - immediately adjacent to Chocorua Lake	Track pollutant attenuation between sites 2 and 3
4	In-lake - 3 meters from culvert mouths	Monitor in-lake pollutant levels

Theoretically, we expect relatively pure water from the the forested sites (#1), a reduction in water quality at the sites located 3 meters downstream of Rt 16 (#2) and a subsequent increase in water quality at the site immediately adjacent to Chocorua Lake (#3) that reflects the pollutant attenuation associated with the implemented BMPs. The final in-lake sampling site located adjacent to each culvert (#4) will track the nearshore physiochemical variables outlined in table 12. We intend to collect samples on a maximum of 4 sampling dates although the ambient weather patters will ultimately dictate the actual number of sampling dates.

Streamflow measurements will be collected using a Global Flow FP101 digital water velocity meter at each sampling location during each sampling trip. Stream geometry measurements (water depth and stream width) will be collected concurrently with the velocity measurements to facilitate the calculation of water and nutrient loading values at the respective sampling locations. Streamflow measurements will be collected at cylindrical concrete pipes, that run under Rt 16, in each of our six study culverts. Due to irregularities in the stream channel morphology, the collection of streamflow measurements in the cylindrical pipes should most accurately reflect the water volume in the respective culverts.

4.1.2 Sampling Task II – Deep Lake and Major Tributary Sampling

Bi-weekly TP and Secchi Disk transparency data will be collected at the deepest point in Chocorua Lake between June 1 and September 30, 2003. These measurements will reflect the cumulative impact of nutrients and particulate loading on Chocorua Lake (Table 10). TP samples will also be collected at the major lake inlet (Chocorua River) and the lake outlet (@ the Dam) to estimate the nutrient flow-through. The bi-weekly sampling will be used to assess Chocorua Lake's response to nutrient loading and help assess the Chocorua Lake's trophic status. The water quality data collected at the deep sampling site will be compared to the annual water quality data that have been collected in Chocorua Lake since 1982; the comparison of current and historical water quality data will help discern the any water quality changes that have occurred since the implementation of the Rt 16 BMPs (i.e. has the water quality improved).

4.1.3 Sampling Task III- Integrated Nutrient Sampling of Pre and Post Wetland Impacts

The Chocorua Lake nutrient/water budget study (Schloss, 2000) disclosed the significant protective functions that the Chocorua River wetlands play. The fact that the Route 16 drainage area

Table 10. Sampling Task II Field Sampling Summary

Analyte	Total no. of sampling locations	Number of sampling events	Total number of samples possible	Total number of samples analyzed	Completeness
Total Phosphorus	3	11	33	24	73.0%
Secchi Disk Transparency	1	11	11	11	100.0%

is one of the few contributing subwatersheds not buffered by wetlands implies that nutrient reductions from the well buffered Chocorua River will have large and positive (i.e. nutrient attenuation) impacts on sediment and nutrient load into Chocorua Lake. In-lake periphyton (attached algae) sampler deployments at various points within Chocorua Lake will help determine the in-lake response to nutrient loading. Supplemental TP, TN, SRP, turbidity, temperature and specific conductivity data will be collected to assess any correlations between the periphyton data and ambient physical and chemical parameters. Relatively low nutrient levels correlated well to local nutrient runoff conditions and periphyton productivity as measured on artificial substrates deployed in Sebego Lake Maine (Ken Wagner, personal communication regarding similar study on Sebago Lake). The typical Sebago Lake TP concentrations, that measure between 3 and 5 micrograms per liter, are similar to the TP concentrations typically measured in Chocorua Lake. The periphyton sampler data along with SRP, TN and TP samples, taken on a bi-weekly basis, should allow for a better understanding of in-stream nutrient loss, wetland nutrient assimilation rates and in-lake nutrient response. The study results will also be helpful in future modeling efforts of both watershed loadings and lake response/diagnostics.

The latest version of the EPA Rapid Bioassessment Protocol for use in Streams and Wadeable Rivers (Barbour et al, 1999; http://www.epa.gov/owow/monitoring/rbp/) lists the advantages of using an artificial substrate:

- *Artificial substrates allow sample collection in locations that are typically difficult to*

Table 11. Sampling Task III: Sampling locations and Sampling Rationale.

Site #	Location	Sampling Rationale
CR1	Upstream of Rt 16 (100% forested)	Minimally impacted Chocorua River reference site. data from this site will be compared to all other sites located along the Chocorua River.
CR2	Upstream of 1st wetland complex with some scattered houses within 100 meters of the river.	Data collected at this site will be compared to the data collected at Site 3 to assess the differences between the pre and post wetland water quality data.
CR3	Immediately downstream of the 1st wetland complex with some scattered houses within 100 meters of the river. This site is located about 100 meters upstream of the second Chocorua River wetland complex.	Data collected at this site will be compared to the Site 2 data discussed above. This site will also serve as the upstream sampling site for the second Chocorua River wetland complex.
CR4	Immediately downstream of the second wetland complex. This site There is a single house and a dirt road within 100 meters of this site. This is a relatively pristine site and the impact of the nearby road and house are considered negligible.	Data collected at this site will be compared to the Site 3 data to assess the differences between the pre and post wetland water quality data.
CR5	Immediately upstream of the third wetland complex	Data collected at this site will be compard to the data collected at Site 6 to assess the differences between the pre and post wetland water quality data. The distance between Site 4 and the third wetland complex is approximately 1/2 mile. Thus, site 5 was selected to more accurately reflect the conditions immediately upstream of the third wetland complex.
CR6	Immediately downstream of the third wetland complex located at the mouth of the Chocorua River, adjacent to Chocorua Lake.	Data collected at this site will be compared to the data collected at Site 5 to assess the differences between the pre and post wetland water quality data.
CR7	Deepest fringe of the littoral zone located in the northwest quadrant of Chocorua Lake.	Data collected at this site will monitor Chocorua Lake's reaction to nutrient inputs. This site is located in a segment of Chocorua Lake characterized by extensive riparian vegetation and few scattered homes located approximately 100 meters from the lake. This site will reflect Chocorua Lakes' overall reponse to nutrient loading and will be compared to site 8 (downstream) to assess the degree of nutrient retention in Chocorua Lake.
CR8	Fringe of the littoral zone located immediately upstream of the Chocorua Lake outlet.	Data collected at this site will assess the nutrient content in Chocorua Lake and serve as an in-lake reference site. This in-lake site is surrounded by extensive tree and herbaceous ground cover.

sample effectively (e.g., bedrock, boulder, or shifting substrates; deep or high velocity water).

- *As a "passive" sample collection device, artificial substrates permit standardized sampling by eliminating subjectivity in sample collection technique. Direct sampling of natural substrate requires similar effort and degree of efficiency for the collection of each sample. Use of artificial substrates requires standardization of setting and retrieval; however, colonization provides the actual sampling mechanism.*

- *Confounding effects of habitat differences are minimized by providing a standardized microhabitat. Microhabitat standardization may promote selectivity for specific organisms if the artificial substrate provides a different microhabitat than that naturally available at a site.*

- *Sampling variability is decreased due to a reduction in microhabitat patchiness, improving the potential for spatial and temporal similarity among samples.*

- *Sample collection using artificial substrates may require less skill and training than direct sampling of natural substrates.*

Disadvantages listed involve logistics (having to return to the deployments), danger of loss or disturbance due to vandalism, the substrate's ability to influence periphyton community structure (ie: attached forms over motile forms), and a compromise of the usefulness or applicability of the siltation index. The objectives and goals of this study require the collection of the artificial substrates every two weeks through the study period. These retrievals will only involve removing, and replacing, the growth tiles (described later) from which the periphyton samples will be collected. Thus, the artificial substrates will otherwise remain in the same positions for the duration of the study. The community structure sampled from the periphyton samplers will be similar and not include motile forms is actually a plus as it will allow us to better discover how well the procedure allows for stream reach nutrient response assessment. As a siltation index is not a parameter of concern for this part of the study, and more direct measures of siltation from the BMP evaluations will be measured by direct turbidity of pre- and post structure measurements, the last disadvantage is moot.

The proposed periphyton (attached algae) sampler deployment brackets a series of three wetland complexes located along the Chocorua River (Figure 32). Total phosphorus data collected during the Chocorua Lake water/phosphorus budget (Schloss, 2000) indicate the second wetland complex located between Sites 3 and 4 was a nutrient sink during the 1996 hydrologic year. This study expands upon the functionality of the three major wetland complexes that are bracketed by upstream and downstream periphyton samplers (Figure 32 and Table 11). The first wetland complexes is bracketed by Sites 2 and 3, the second wetland complex is bracketed by Sites 3 and 4 and the third wetland complex is bracketed by sites 5 and 6. Two additional in-lake sampling sites (Sites 7 and 8) are positioned at the fringe of the litorral zone in the northwestern and the southern end of Chocorua Lake. Site (#7) is located in the northwestern quadrant of Chocorua Lake that is a compromise between the optimal, northernmost, sampling location and an attempt to minimize vandalism. A local resident, Toby Page of the CLA, will overlook the Site 7 periphyton sampler that is located adjacent to his property that will minimize the potential for lost data due to vandalism or other equipment failure. The second in-lake periphyton sampler (#8) will be located just above the dam outlet to estimate the nutrient processing that occurs within Chocorua Lake. The in-lake nutrient processing will be estimated by comparing the difference between the Site 7 and Site 8 water quality data. The periphyton samplers will be left in place throughout the growing season for 6 sampling cycles at each of the eight sampling sites (Table 12).

Streamflow measurements, stream channel morphology measurements and staff gauge readings will be collected at sites 1 through 5, on each of the six sampling dates, to compute

Table 12. Sampling Task III Field Sampling Summary

Analyte	No. of sampling locations	No. of samples per sampling date per site	Number of sampling dates	Number of field duplicates	Number of blanks	Total number of samples to lab
Total Phosphorus	8	1	6	1/sample date = 8	1/sample date = 8	64
Soluble Reactive Phosphorus	8	1	6	1/sample date = 8	1/sample date = 8	64
Periphyton (chlorophyll *a*)	8	3	6	1/sample date = 8	1/sample date = 8	160
Orthophosphate	8	1	6	1/sample date = 8	1/sample date = 8	64
Turbidity	8	1	6	1/sample date = 8	1/sample date = 8	64
Conductivity	8	1	6	1 re-measurement/ sampling location	NA	measured *in situ*
Temperature	8	1	6	1 re-measurement/ sampling location	NA	measured *in situ*
Streamflow	5	1	6	1 re-measurment/ sampling date	NA	measured *in situ*

discharge and nutrient loading values on the respective sampling dates. Due to excessive depth at site 6, no discharge data will be collected at this site.

For all samplers the artificial substrate chosen is Styrofoam insulation (Owens-Corning, 1 inch thickness). This material has been used successfully for in lake studies in Maine and New York (Ken Wagner, personal communication). The Styrofoam insulation serves as a "growth plate" that will periodically be scraped off with a 2" wide scraper (razor) blade, to remove the periphyton growth, concentrated onto a 0.45 micron mesh filter and subsequently analyzed for the chlorophyll *a* pigment content. Note: the chlorophyll *a* samples will be scraped under subdued lighting and upon filtration of the periphyton samples the filters will be folded in half and wrapped in aluminum foil to avoid deleterious light exposure. The chlorophyll *a* content will measure the periphyton standing crop that integrates the "long-term" nutrient loading at the respective deployment sites. The periphyton (Styrofoam) samplers are easy to deploy, replace and will facilitate data collection for the duration of this study. The inherent buoyancy of the material also allows for lake deployments without the use of floats that would block out sunlight to the sampler. For stream deployments the material will be cut to 4" by 8" blocks that will be attached to an anchor weight consisting of a similar sized landscape brick (red) using a wire harness. For in-lake deployments a two piece wooden x-frame will be attached with eyebolts that will allow the attachment of anchors and line to maintain the sampler at the selected depth and location. The periphytic algae for chlorophyll *a* analysis will be obtained over a standardized 2" x 4" surface area (51.6 cm^2) by drawing the 2" wide razor blade over the entire width (4") of the periphyton samplers. This method was chosen instead of employing pre-scribed quadrants on the samplers since we found the marking process creates an indentation in the Styrofoam surface which tends to trap sample. This method approach also allows for negating the impact of grazing insects (i.e. *Heptageneid* mayflies) and the interference of patches of filamentous green algae (*chlorophyceae*) as we will select our transects based on the most representative areas on each periphyton sampler.

All stream samplers will be deployed at approximately the same depth and sun exposure direction in the moderate to low energy area of the stream channel (Barbour et al, 1999). All in-lake samplers will be deployed at depth of one meter in an area away from dense plant beds. Other multiple deployment periphyton studies have been criticized for comparability between sites due to temperature and sunlight differences. We will thus monitor incident light, temperature and humidity on a data logger (Onset Computer Corporation Model HO8-004-02) fitted into a clear waterproof submersible case (SUBCASR-CLR) at each deployment site. The data logger will be attached to the periphytometer so it remains downstream and does not shadow the monitor. The temperature and light logs will be used to compare the conditions facing the samplers. The relative humidity measurement will monitor the water tightness of the case. Specifications of these sensors are listed below (Table 13).

TABLE 13. Specifications of the Onset Model HO8-004-02 (provided by manufacturer)

Measurement Range	*Accuracy*
Temp: -4°F to +158°F	**Temp:** ±1.27°F
RH: 25% to 95% non-condensing	**RH:** ±5%
LI: 2 to 600 Lumens/ft^2	**LI:** ±2 lumens/ft^2

5.0 Sampling Procedures and Requirements

5.1 Sampling Procedures

5.1.1 Task I: Post BMP Installation Monitoring/Evaluation of Route 16 Culverts.

The Route 16 culvert samples will consist of the collection of TP, TN and TSS samples as well as the collection of specific conductivity (SPCD), turbidity, streamflow and stream morphology data during each sampling trip (Table 8).

The temperature and SPCD data will be collected in-situ at all sites along the sampling stations. The temperature and SPCD measurements will be recorded on the "Chocorua Lake: Rt 16 BMP Monitoring/Evaluation datasheet" (Appendix D).

Soluble reactive phosphorus, TP, TN, TSS and turbidity grab samples will be collected in the appropriate sampling bottles by pointing the bottles upstream and carefully placing the bottles into the water and allowing the bottles to fill. If the field technician inadvertently disturbs the benthic substrate during the collection process the sample will be discarded, the contaminated sampling bottle will be deemed unusable and the collection procedure will be repeated with an uncontaminated bottle by collecting a water sample 10 cm upstream of the previous sampling location.

The Chocorua Lake culvert sampling will be conducted during or immediately following rainfall events during which peak runoff and peak phosphorus and sediment loading typically occur. The CFB field team will attempt to collect the phosphorus samples during the most intense rainfall period although the sampling period might include the collection of samples immediately following the storm event.

5.1.2 Task II: Deep Lake and Major Tributary Sampling.

Grab total phosphorus data will be collected at the deep in-lake sampling location as well as near-shore sampling locations located at the major tributary inlet (Chocorua River) and at the Dam (outlet). The TP samples will be collected from a canoe at pre-determined coordinates through triangulation. The canoe will be securely anchored at the appropriate sampling location and a water sample will be collected at a depth of 0.5 meters using a vertical Van-Dorn sampler. The Total Phosphorus samples will be frozen at -20°C until subsequent analysis (Table 14).

5.1.3 Task III: Integrated Nutrient Sampling of Pre and Post Wetland Impacts.

Artificial periphyton colonization substrates will be placed at stream sites after the period of

Table 14 Sample locations and requirements

Analytical Parameter	Collection Method	Method SOP	Sample volume/ area	Container size and type	Preservative	Max. holding time and storage requirement
Chlorophyll	AFS *	9.1c	51.6 cm^2	NA *	NA	28 days @ -20°C
Total Phosphorus	grab	9.1a	250 ml	PP	H_2SO_4 to pH<2	28 days @-20°C
Soluble Reactive Phos.	grab	9.1a	250ml	PP ^	NA	7 days @-20°C
Total Nitrogen	grab	9.1a	250 ml	PP	H_2SO_4 to pH<2	28 days @-20°C
Turbidity	grab	9.1a	2 Liters	PE	NA	24 hrs @4°C
Total Suspended Solids	grab	9.1a	2 Liters	PE	NA	24 hrs @4°C
Conductivity	in-situ	9.1a	NA	NA	NA	NA
Temperature	in-situ	9.1a	NA	NA	NA	NA

* denotes samples will be scraped from an artificial substrate (AFS) and subsequently filtered onto a 0.45*u*m HAWP04700 Millipore membrane filter. A Nalgene hand pump will be transported into the field, where the samples will be filtered. The samples will subsequently be placed loosely in plastic bags containing Drierite and place in a ice-filled cooler.
^ SRP samples will be field collected in 500 ml acid washed PP bottles and filtered through Millipore HAWP04700 membrane filters immediately upon return to the CFB laboratory. The filtrate will be collected in a 250ml acid washed bottle and stored at –20°C until analysis. All filtration equipment will be acid washed prior to use.

peak spring runoff. The artificial substrates will be positioned at a similar depth and direction to sunlight exposure, at a slight angle to deter sediment settlement, in an inconspicuous place to minimize interference or vandalism. The artificial substrates will also be marked do not disturb and information for returning found samplers will be attached. In-lake periphyton samplers will be deployed at the same time. Every two weeks the samplers will be checked, the substrate will be digitally photographed to show coverage patterns, the loggers will be downloaded and a subsample of the substrate will be scraped and the algae collected.

Periphyton will be collected using a straight edged blade to scrape off a predetermined area of accumulated algae into a filtration flask containing a 47mm diameter 0.45 micron Type HA Millipore membrane filter. The scraped area and blade will be rinsed with distilled water into a Nalgene filtration flask (Cat # 310-4000) to collect the periphyton sample. The rinsate will be field filtered through a Millipore membrane by applying a vacuum generated by a Nalgene hand vacuum pump. The filter will then be placed on the back of an archive quality (acid-free) paper insert label

containing the sample information written in pencil. The filter and insert label are then placed into an opaque plastic container with Drierite desiccant and placed on ice in the field until it can be transferred to a freezer. Information written on the insert label will be repeated on the field sheet to include date, time of sampler removal, scraping and re-deployment, sample number, site number, field personnel, area scraped and comments. Prior to the periphyton sampler re-deployment, all remaining algae will be cleaned and scrubbed off, or a new substrate will be deployed.
At least 5% of all samples collected will be field duplicates. Occasionally other samples of the periphyton may be collected for later identification but that is beyond the intended scope of this project. Frequency of sampling is expected to be every other week but might be modified dependent on actual growth conditions.

SRP, TP and TN and turbidity grab samples will be collected in the appropriate sampling bottles by pointing the bottles upstream and carefully placing the bottles into the water and allowing the bottles to fill. If the field technician inadvertently disturbs the benthic substrate during the collection process the sample will be discarded, the contaminated sampling bottle will be deemed unusable and the collection procedure will be repeated with an uncontaminated bottle by collecting a water sample 0.5 meters upstream of the previous sampling location.

5.3 Cleaning and Decontamination of Equipment/Sample Containers

All digital field-sampling probes will be thoroughly rinsed with de-ionized water before each sampling trip and immediately upon return to the laboratory. The pre-calibration and post-calibration of all digital sampling equipment, and accompanying pre-calibration and post-calibration logs, will assure the sampling equipment has been properly cleaned and inspected.

All sample bottles will be rinsed three times with reagent grade de-ionized water. The nutrient sampling bottles will be washed in a 30% hydrochloric acid solution prior to the de-ionized water rinse to assure the sampling bottles are appropriately prepared for trace nutrient concentrations.

5.4 Field Equipment Calibration

The YSI 30 temperature probe will be checked and inter-calibrated, using an NIST certified thermometer, at the beginning and the end of this project, as well as, whenever the batteries are changed. A calibration check will also be performed after each sampling trip to assure the digital temperature meter has not drifted by more than 0.1°C. If readings differ by more than 0.1° C the discrepancy will be noted on the instrument calibration maintenance log and the meters will be re-adjusted and calibrated per the manufacturer's instructions. The acceptance criteria for the temperature data will be set as <= 0.2°C. All temperature data that exceed our acceptance criteria, collected since the last acceptable calibration check, will be considered suspect and will be discarded.

The YSI 30 specific conductivity probe will be calibrated immediately prior to each sampling trip, and whenever the batteries are changed, per the manufacturer specifications outlined in Appendix B. A set of calibration standards will also be analyzed at the end of each sampling trip to assess the degree of "drift".

The Global Flow FP101 will be calibrated whenever the batteries are changed per the manufacturers "Set Up" directions (Appendix B - 3). A lab technician will also calibrate the Global Flow FP 101 streamflow meter immediately prior to each sampling trip. All calibration checks will be documented in the calibration/maintenance log (Appendix C).

The temperature data measured with the Onset HO8-004-02 meter will be compared to a NIST certified thermometer before deployment. If the temperature readings differ by more than 1.3°C the discrepancy is noted on the instrument calibration maintenance log (Appendix C) and the temperature is adjusted by a professional technician. The emphasis here will be more to standardize the loggers among one another, as consistency among the meters is critical in doing the compensation for the physical conditions among the periphyton (Task III) sampling sites. The Onset Model H08-004-02 temperature readings are compared to temperature readings obtained with a NIST certified thermometer after they are retrieved at the end of the study. Discrepancies between the values measured with the Onset Model H08-004-02 meter and the NIST certified thermometer will be documented in the calibration log.

5.5 Field Equipment Maintenance, Testing and Inspection Requirements

As part of our routine inspection and preventative maintenance program the laboratory manager, Bob Craycraft, conducts a variety of tests on our laboratory and field equipment and the data are recorded on a maintenance log (Appendix C). Maintenance, repair and adjustments that require a professional technician are conducted by either our instrument repair facility located at the University of New Hampshire Department of Chemistry or by authorized factory technicians of the particular instrument's manufacturer. All maintenance manuals, documentation and schematics as well as the instrument logs are kept on file by the CFB laboratory manager.

On a monthly basis all electronic cables will be checked for stretching, twists and breaks. Cable and line markings that indicate depth will also be checked at this same frequency.

Probes for field and laboratory instrumentation will be visually checked before and after each use. Replaceable components such as electrolytes and membranes will be replaced on a schedule consistent with manufacture's recommendations unless inspection or performance indicates a need for more frequent replacement. Fresh solutions and membranes are kept on hand in the lab and in the field. A replacement probe for each instrument is always available. Expendable and refurbishable probes are used up to the recommended times of their manufacturers specifications and will be replaced or refurbished at the beginning of this project.

5.6 Inspection and Acceptance Requirements for Supplies/Sample Containers

Conductivity standard reference materials (SRMs) are dated upon receipt and are stored per the manufacturers recommendations. These dates are checked against manufacturers expiration dates and the materials are discarded before the expiration dates are reached. The standards used by our laboratory are NIST certified or certified (analyzed) by the supplier (Fisher Scientific or Sigma Chemical) as NIST traceable. Any broken, unsealed or suspect materials are returned to the manufacturer for replacement. When SRM is used it is compared to the previous SRM supply to check for consistency/contamination.

Any sample bottles that appear damaged and any bottles with broken seals or caps are not used for sample collection. If there is any doubt that a sampling bottle was inadequately washed it will be set aside and rewashed to assure all contaminants have been removed.

6.0 Field Analytical Method Requirements

6.1 Field Analytical Methods and SOPs

6.1.1. Periphyton Samplers

After the periphyton samples are collected in accordance with sampling Task II, data will be downloaded from the HOBO H08-004-02 (temperature/light meters) during each stream visit (approximately two weeks) using an HPO Shuttle (part # H09-002-08). At the site, the field technician will carefully remove the temperature/light meter from the water without touching the upper half of the protective waterproof case (leave the biofilm intact). Place the meter on a flat surface immediately adjacent to the in-stream sampling location and allow the meter to record incident light for a period of 5 minutes. After the 5 minute recording period, remove the meter from the clear submersible case (Part # SUBCASE-CLR) and place the meter on the ground for an additional 5 minute period and allow the meter to record the incident light. The incident light data collected over the 5-minute intervals will help determine any light loss due to fouling over the course of the prior two-week deployment period. While the light meter is recording incident light you should rinse off the clear submersible case using de-ionized water (DI H_2O), dispensed from a Nalgene squirt bottle, and wipe the case with paper towels. Make sure all fouling agents have been removed from the protective case, and make sure the inside of the case is dry, prior to unit redeployment. After recording the post-deployment incident light (with and without the case) insert the download cable into the data transfer interface. Once a connection has been established between the shuttle and the temperature/light meter, initiate the data transfer button and wait for the "successful" light to turn orange next to "successful" on the side of the shuttle. If a "comm failure" message indicator appears remove the download cable. Patiently repeat the above steps until the data are downloaded. Once the data are successfully downloaded, select "relaunching" from the menu (the orange light will blink if successful) and carefully insert the HOBO temperature/light meter into the submersible case. Reattach the waterproof case to the periphyton sampler. Note: make sure you insert the light sensor face up, otherwise data will be lost. Before leaving the site make sure the waterproof case is vertical and the periphyton sampler is in its origional location.

6.1.2. Temperature and Conductivity Measurements

The most downstream sampling site will always be sampled first, followed by the next sampling location immediately upstream until the entire stream/culvert stretch has been sampled. The field technicians will always stand downstream of the sampling location when collecting the water samples or conducting in situ sampling. Prior to collecting in situ temperature and conductivity measurements contaminants will be cleared from the probe by dipping the probe in the water three times at each sampling location. The probe will then be placed in the water at a depth of 4-6 inches and allowed to stabilize, the reading will be recorded on the corresponding datasheet. The temperature/conductivity probe will then be raised out of the water and then placed back into the stream to obtain a second set of measurements that will be recorded on the corresponding datasheet.

6.1.3. Discharge Measurements

Sampling Task I and II stream channel (culvert) dimensions will be collected by measuring the culvert diameter and the culvert depth and recording those values on the corresponding datasheet. Prior to attaining the flow measurements inspect the Global Flow FP101 propeller to assure it turns freely prior to every measurement. If necessary, rinse the meter with water to remove any particulate debris. A streamflow measurement will be collected by positioning the tip of the velocity meter at six tenth of the stream depth (i.e. if the water is 10 cm deep the tip of the meter should be positioned at a water depth of 6 cm) and following these steps:

1) Point the arrow (on the bottom of the probe) downstream.
2) Press the right button until the "V" for velocity appears. The top number is the instantaneous velocity. Push the left button to toggle between maximum "mx" and the average "av" velocity. The probe will be set to the "av" velocity setting.
3) Push both the right and left buttons simultaneously and release the buttons to zero the meter and begin recording the average velocity measurement
4) Collect the velocity measurement for a minimum of 40 seconds or until the average velocity stabilizes. A stable velocity measurement is one that varies by no more than 10% over a 10 second period.
5) Record the velocity measurement on the datasheet.

6.2 Field Analytical Method/SOP Modifications

No SOP modifications.

6.3 Field Analytical Instrument Calibration

Refer to section 9.3.

6.4 Field Analytical Instrument/Equipment Maintenance, Testing and Inspection Requirements

All field Analytical Instruments will be checked for "low battery" indicators immediately prior to each sampling trip and upon return to the laboratory (post sampling). When the "low battery" indicator appears the laboratory technician will replace the batteries.

Maintenance, repair and adjustments that require a professional technician are conducted by either the instrument repair facility located at the University of New Hampshire Department of Chemistry or by authorized factory technicians of the particular instrument's manufacturer. The YSI 30 cable will be checked before and after each sampling trip and checked for stretching, twists and breaks. If the YSI 30 temperature readings differ by more than 0.1°C, relative to an NIST thermometer, the discrepancy is noted on the instrument calibration maintenance log and the temperature is adjusted by a professional technician.

When temperature readings, collected with the Onset Model H08-004-02 temperature meters, differ from an NIST certified thermometer by more than 1.3°C the discrepancy is noted in the instrument calibration maintenance log and the temperature is adjusted by a professional technician.

6.5 Field Analytical Inspection and Acceptance Requirements for Supplies

Field calibration solutions are dated upon receipt. These dates are checked against manufacturers expiration dates and the materials are discarded before the expiration dates are reached. The calibration solutions used are standard reference materials (SRMs) that are NIST certified by the supplier (Fisher Scientific or Sigma Chemical) as NIST traceable. Any broken, unsealed or suspect materials are returned to the manufacturer for replacement.

7.0 Fixed Laboratory Analytical Method Requirements

7.1 Fixed Laboratory Analytical Methods and SOPs

In most cases, the procedures used in the laboratory will follow standard methodology as described in Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, WPCF 1998; 20th edition) or Methods for the Chemical Analysis of Water (US EPA 1999). Our second derivative spectrophotometric total nitrogen procedure is currently scheduled to be included in the upcoming release (21st edition) of Standard Methods so alternatively, the techniques documented in peer reviewed journals will be employed (Appendix D). Table 7 summarizes the parameters to be analyzed and the analytical reference sources. Appendix A includes a series of analytical procedure sheets that are used to assure consistency among our laboratory technicians.

Nutrient and chlorophyll data will be measured on highly sensitive spectrophotometers (bandwidth <= 2nm) using cuvettes with 5 – 10 cm pathlengths as outlined in Table 15. These highly sensitive spectrophotometers facilitate the collection of chlorophyll data and also maximize the sensitivity of other analytes that are analyzed in the CFB laboratory.

Table 15. Laboratory Spectrophotometers and analytical criteria for study analytes

Spectrophotometer	Analyte Measured	Bandwith	Cuvette Type	Cuvette Pathlength
* Cary 50 Scanning Spec.	Total Nitrogen	1.7 nm	Quartz	5 cm
* Milton Roy 1001+	Chlorophyll	2.0 nm	Near UV	5 cm
* Milton Roy 1001+	Total Phosphorus	2.0 nm	Near UV	10 cm
* Milton Roy 1001+	Soluble Reactive Phosphorus	2.0 nm	Near UV	10 cm

7.2 Fixed Laboratory Analytical Method/SOP Modification

The extraction of the periphyton (chlorophyll) samples has been modified from the APHA Standard Methods: 100200H.1 (APHA, 1998) to maximize the rupture of algal cells and to maximize the subsequent extraction of the chlorophyll pigments. The final analysis of the chlorophyll extract does follow Standard Methods: 100200H.2 (APHA, 1998).

Chlorophyll Extraction:

1) Frozen samples will be analyzed within 28 days of collection.
2) Algal cells will be disrupted in a glass centrifuge tube using an ultrasonic probe while held in an ice-bath.
3) The algal samples will be brought to 15 ml volume with 90% acetone and allowed to "steep" refrigerated for 24 hours in the dark.

4) Samples will be centrifuged and analyzed according to Standard Methods: 100200H.2 (APHA, 1998).
5) Chlorophyll biomass will be measured spectrophotometrically and calculated as micrograms chlorophyll *a* per square centimeter by taking account of area of periphytometer scraped, volume of extract, absorbtivity of the chlorophyll *a* molecule in 90% acetone, and pathlength of the cuvette.
6) The chlorophyll *a* results will be generated using the monochromatic spectrophotometric equation with a pheophytin correction:

$$\text{Chlorophyll } a = \frac{26.7 * (664_b - 665_a) * \text{extract volume}}{\text{Sample volume} * \text{path length}}$$

where b = before acidification
a = after acidification

8.0 Quality Control Requirements

8.1 Sampling Quality Control

Flow measurements:

During each sampling trip a minimum of two readings will be duplicated by two different field technicians to assess the precision of the measurements. The measurements collected by the two different field technicians will also assess the consistency among our field team staff. If the duplicate readings differ by more than 10%, the field technicians will discuss the procedures with the Project Manager until an understanding is reached. Suspect measurements might be discarded or might be kept depending on the result of the conversation. Duplication will also occur when Staff gauge readings (previously installed for the nutrient budget project) will be collected to document the stream depth for each gauged point. The staff gauge height and concurrent streamflow/culvert geometry measurements, collected during each sampling trip, will be used to assure the gauge height/discharge relationship is accurate. If a heavy runoff event alters the stream channel morphology, a new rating curve will be generated for the applicable (post channel alteration) time period.

Sample collection:

Field duplicates will be collected at least once during each field sampling trip and will account for a minimum of 5% of the collected samples during a single sampling trip. Precision will be calculated using the RPD between the replicate samples. If the RPD exceeds the MPC (Table 6), the sample results will be considered questionable and the Project Manager will consult the UNH laboratory manager to determine if the data quality has been compromised, in which case the suspect results will not be used.

8.2 Analytical Quality Control

8.2.1 Field Analytical QC

Replicate in-situ measurements will be measured on 100% of the samples. If the precision outlined in Table 6 is exceeded the sample results will be considered questionable and the Project Manager will consult the UNH laboratory manager to determine if the data quality has been compromised, in which case the suspect results will not be used.

8.2.2 Fixed Laboratory QC

Table 16 summarizes the Fixed Laboratory QC SOPs that are employed by the University of New Hampshire CFB laboratory. The table lists the minimum level of replication, lab reagent blank analysis and lab fortified matrix spike analysis while more frequent QC samples might be run at the discretion of the laboratory manager.

Replicate turbidity measurements will be measured on 100% of the samples. If the RPD is greater than 15% the sample results will be considered questionable and the Project Manager will consult the CFB laboratory manager to determine if the data quality has been compromised, in which case the suspect results will not be used.

9.0 Data Acquisition Requirements

Historical total phosphorus, specific conductivity, temperature and discharge data were

Table 16. Fixed Laboratory Analytical QC Sample Table

Analyte	Laboratory Duplicate	lab fortified matrix spike	lab fortified blank (QC Standard)	lab reagent blank
Total Phosphorus	100%	5%	B & E *	B & E *
Soluble Reactive Phosphorus	100%	5%	B & E *	B & E *
Total Nitrogen	100%	5%	B & E *	B & E *
Turbidity	100%	NA	B & E *	B & E *
Total Suspended Solids	10%	NA	B & E *	B & E *

* B and E denotes QC standards and reagent blanks will be analyzed immediately after instrument calibration at the beginning (B) and the end (E) of each analytical run.

collected during a Chocorua Lake water/nutrient budget between 1996 and 1997 (Schloss, 2000). The water quality data generated during the nutrient/water budget will serve as baseline data for the proposed Chocorua Watershed Project Phase II study. Data collected during the 1996/1997 Chocorua Lake nutrient budget included sampling of the Rt 16 drainage culverts (Figures 21 and 22) as well as the sampling of various points along the Chocorua River (Figure 32; Sites 3-5) that will serve as baseline data for this proposed study. Additional total phosphorus, total nitrogen, soluble reactive phosphorus, TSS, turbidity, specific conductivity, temperature and discharge data have been collected in the Rt 16 drainage culverts (figures 28 and 29) and at the Chocorua River sampling sites (Figure 32; Sites 1-8) have been collected since 1997 (data unpublished). These supplemental physio/chemical data have been collected during various stages of the BMP implementation adjacent to Rt 16 and will help assess the ability of the Task I BMPs to attenuate pollutants. Data collected at the periphyton sampling sites (Task II) since 1997 will serve as a baseline to better understand the nutrient and physical changes that occur as the water travels from the headwaters to the mouth of the Chocorua River and as the water flows from the north to southern end of Chocorua Lake. Preliminary periphyton data collected at the proposed Task II sampling locations in 2001 will also be used to assess the functionality of the wetland complexes at attenuating nutrients as well as provide some indication of interannual periphyton biomass (measured as total chlorophyll) variations.

Daily precipitation data, collected by the National Oceanic and Atmospheric Administration at the Tamworth 3 and Tamworth 4 climatological sampling stations (National Oceanic and Atmospheric Administration: http://cdo.ncdc.noaa.gov/plclimprod/plsql/poemain.poe), have been used to calculate water and phosphorus loading values at the Chocorua Lake tributary sampling sites between 1996 and 2002. A supplemental HOBO rain gauge was deployed approximately 0.25 miles west of Chocorua Lake in September 2001 (Figure 19). The HOBO rain gauge collects rainfall data in 0.01" increments and will be used to more accurately assess the ambient rainfall within the Chocorua Lake watershed during the proposed Phase II study period.

Historical water quality data collected by the UNH LLMP since 1982 (Craycraft and Schloss, 2002) will provide an in-lake record of the water transparency and total phosphorus content documented in Chocorua Lake. These data will provide a long-term record of water quality parameters to which the in-lake water transparency and total phosphorus data, generated through the current study can be compared. Supplemental Chocorua Lake data historically collected by the New Hampshire Fish and Game Department (Hoover, 1938; Newell, 1970) and the New Hampshire Department of Environmental Services (Estabrook et. al., 1993; New Hampshire Water Supply and Pollution Control Commission, 1981) will also be reviewed and will serve as baseline data. Care will be taken when comparing the results among studies due to methodological variations and differences in the sampling frequencies. Differences between data generated in the proposed Chocorua Watershed Phase II project and the historical data will be included in the final summary report.

10.0 References

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APPENDIX A: Discussion of water quality parameters

Temperature

The water temperatures commonly fluctuate with the seasons but are also related to physical characteristics such as the presence or absence of riparian (streamside) vegetation, as well as, the source of recharge that could include impoundment effluent or groundwater inflows. Generally speaking, streams characterized by extensive riparian cover tend to be cooler that streams where the riparian cover has been removed. Likewise, streams fed by surface water tend to be warmer than streams that are fed by groundwater. Plant growth is commonly related to water temperatures and generally speaking, aquatic plant and algal growth is accelerated as the water temperatures increase.

Light

The amount of light that reaches the water body can influence the distribution and types of primary primary producers that flourish. Just like terrestrial plants, many aquatic plants are shade intolerant and thus will be absent or highly reduced in regions of dense forest canopy. As light reaches the surface waters it will also increase the water temperatures and influence the types of organisms that inhabit the specific location. Light/temperature meters were deployed with each of the periphyton (attached algae) samplers in this study to, as best as possible, compensate for temperature and light variations among sampling locations.

Total Suspended Solids (TSS)

Total Suspended Solids are measured by filtering the contents of a water sample through a filter with a standardized mesh size. The particulate matter retained on the filter constitutes the suspended solids which are subsequently quantified via measurement on an analytical balance. In pristine lakes and streams, where the amount of algal growth, silt and other particulates are minimal; the Total Suspended Solids are oftentimes near or below 2 mg/L during baseflow conditions. During high discharge periods such as spring melt and intense storm events, the amount of suspended solids oftentimes increases due to the natural displacement of organic (i.e. leaves, decaying matter) and inorganic (i.e. sediments) debris. However, when land-use alterations occur that do not employ proper erosion control measures and increase the amount of overland flow we oftentimes observe increases in the amount of Total Suspended Solids.

The amount of Total Suspended Solids can also reflect natural seasonal cycles. For instance, the chances that particulate matter will be flushed into our surface waters is oftentimes higher in the spring prior leaf out and the re-growth of annual plants that hold the soil particles in place. Likewise, higher amounts of Total Suspended Solids can also be observed in the fall when leaf senescence adds suspended organic matter to our surface waters.

Turbidity

Turbidity is a measure of suspended material in the water column such as sediments and planktonic organisms. The greater the turbidity of a given water body the lower the Secchi Disk transparency and the greater the amount of particulate matter present. Turbidity is measured as nephelometric turbidity units (NTU), a standardized method among researchers. Turbidity levels are generally low in New Hampshire reflecting the pristine condition of the majority of our lakes and ponds. Increasing turbidity values can be an indication of increasing lake productivity or can reflect improper land use practices within the watershed which destabilize the surrounding landscape and allow sediment flushing into the lake.

While Secchi Disk measurements will integrate the clarity of the water column from the surface waters down to the depth of disappearance, turbidity measurements are collected at discrete depths from the surface down to the lakebottom. Such discrete sampling can identify layering algal populations (previously discussed) that are undetectable when measuring Secchi Disk transparency alone.

Total Phosphorus and Total Nitrogen

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources arise primarily through human related activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton. As little as 10 parts per billion of phosphorus in a lake can cause an algal bloom.

Phosphorus values are generally higher after spring melt, in more pristine lakes, when the lake receives the majority of runoff from its surrounding watershed. The nutrient is used by the algae and plants which in turn die and sink to the lake bottom causing surface water phosphorus concentrations to decrease as the summer progresses. Lakes with nutrient loading from human activities and sources (Agriculture, Logging, Sediment Erosion, Septic Systems, etc.) will show greater concentrations of nutrients as the summer progresses or after major storm events.

Soluble Reactive Phosphorus (SRP)

Soluble Reactive Phosphorus (SRP) is the fraction of the Total Phosphorus pool that is most available aquatic plants and algae; the soluble Reactive Phosphorus is rapidly "consumed" by plant and will rapidly be incorporated into plant biomass. In streams, where the water and nutrients rapidly flush through the system, the SRP is particularly important to primary producers that serve as a food base for foraging insects and other invertebrates.

Discharge

Streamflow, when collected in conjunction with depth contour information, can be used to calculate the volume of water traversing a given stream stretch over a period of time and is referred to as discharge. Knowledge of the streamflow is important when determining the amount of nutrients and other pollutants that enter a lake. Knowledge of the discharge volumes, collected in conjunction with nutrient concentrations, for instance, will provide the information necessary to calculate phosphorus loading values and will in turn be useful in discerning problem areas within a watershed.

Specific Conductivity *

The specific conductance of a water sample indicates concentrations of dissolved salts. Since conductivity readings are temperature dependent, the measurements are commonly adjusted to a "specific" temperature (commonly 25°C) and are referred to as specific conductivity readings. Deicing salt runoff from highways can result in high conductivity values while "leaky" septic systems and fertilizer runoff can also coincide with elevated conductivity readings. Conductivity is measured in micro**mhos** (the opposite of the measurement of resistance **ohms**) per centimeter, more commonly referred to as micro-Siemans (υS).

The specific conductivity will vary naturally among sampling locations due to geological variations and the weathering of minerals. However, in many lakes and streams the specific conductivity is also impacted by human related activities that increase the conductivity above baseline levels. Some lakes and streams experience conductivity "spikes late in the winter and in early spring when large concentrations of road salt enters our surface and groundwater.

APPENDIX B: Summary Data Tables

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts. (Total Phosphorus Summary)

Site	4/26/03 TP (ug/L)	5/12/03 TP (ug/L)	6/1/03 TP (ug/L)	9/4/03 TP (ug/L)	9/23/03 TP (ug/L)	10/15/03 TP (ug/L)
A-1 Forest	11.3	10.9	-----	38.8	44.8	26.6
A-2 Upper	8.5	7.7	1.8	34.3	44.4	24.0
A-3 Lower	12.6	11.6	-----	-----	-----	24.9
A-4 In-Lake	4.3	4.7	8.2	3.8	10.6	8.3
B-1 Forest	8.3	7.1	1.1	25.7	30.3	21.6
B-2 Upper	5.0	4.2	3.1	25.9	32.0	21.0
B-3 Lower	4.1	5.4	7.5	26.2	39.2	26.2
B-4 In-Lake	3.2	3.9	-----	5.0	20.5	4.9
SW-1 Forest	-----	-----	-----	-----	-----	-----
SW-2 Upper	1.5	1.6	1.7	-----	-----	-----
SW-3 Lower	3.2	3.1	1.2	-----	-----	-----
SW-4 In-Lake	4.0	3.3	4.0	3.8	12.8	3.9
C-1 Forest	8.3	7.3	4.6	-----	35.5	33.7
C-2 Upper	4.6	6.4	2.7	-----	36.2	29.7
C-3 Lower	5.5	8.1	4.1	-----	39.3	30.2
C-4 In-Lake	4.5	3.2	4.7	4.3	6.3	16.1
RG-3 Lower	-----	-----	-----	-----	-----	-----
RG-4 In-Lake	3.8	3.9	3.6	3.9	3.7	4.0
MH-1 Forest	15.9	5.2	2.7	20.1	213.8	19.9
MH-2 Upper	18.3	6.1	2.2	22.3	24.3	20.7
MH-3 Lower	9.5	4.5	2.3	14.4	14.4	19.0
MH-4 In-Lake	3.4	3.1	4.8	4.0	13.7	6.2
MH-1 Rt 16	55.9	13.4	1.1	-----	226.9	16.2
MH-1 Pristine	-----	-----	4.9	19.6	71.7	22.6

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts. (Total Nitrogen Summary)

Site	4/26/03 TN (ug/L)	5/12/03 TN (ug/L)	6/1/03 TN (ug/L)	9/4/03 TN (ug/L)	9/23/03 TN (ug/L)	10/15/03 TN (ug/L)
A-1 Forest	170	85	-----	570	644	372
A-2 Upper	181	162	176	524	541	379
A-3 Lower	197	181	182	-----	-----	490
A-4 In-Lake	105	193	52	126	309	144
B-1 Forest	155	185	106	523	536	440
B-2 Upper	90	165	161	444	541	394
B-3 Lower	117	217	-----	526	573	464
B-4 In-Lake	92	190	79	242	359	195
SW-1 Forest	-----	-----	-----	-----	-----	-----
SW-2 Upper	18	171	274	-----	-----	-----
SW-3 Lower	60	12	-----	-----	-----	-----
SW-4 In-Lake	87	217	73	180	236	78
C-1 Forest	126	259	73	-----	541	372
C-2 Upper	108	94	84	-----	541	398
C-3 Lower	74	79	116	-----	526	354
C-4 In-Lake	93	104	-----	313	226	235
RG-3 Lower	-----	-----	79	-----	-----	-----
RG-4 In-Lake	-----	66	69	197	170	131
MH-1 Forest	403	83	233	320	560	476
MH-2 Upper	463	240	197	471	510	277
MH-3 Lower	338	187	185	240	566	242
MH-4 In-Lake	99	148	-----	156	292	124
MH-1 Rt 16	532	697	767	-----	920	688
MH-1 Pristine	-----	-----	229	304	560	248

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts. (Total Suspended Solids Summary)

Site	4/26/03 TSS (mg/L)	5/12/03 TSS (mg/L)	6/1/03 TSS (mg/L)	9/4/03 TSS (mg/L)	9/23/03 TSS (mg/L)	10/15/03 TSS (mg/L)
A-1 Forest	1.4	-----	-----	4.0	5.1	1.7
A-2 Upper	1.1	0.0	0.6	2.5	4.7	1.9
A-3 Lower	3.8	-----	-----	-----	-----	0.9
A-4 In-Lake	0.7	0.9	1.3	0.4	1.1	3.5
B-1 Forest	0.5	-----	-----	0.7	1.5	1.4
B-2 Upper	0.4	0.0	0.4	0.8	0.2	1.5
B-3 Lower	1.0	0.3	0.7	1.0	6.4	2.2
B-4 In-Lake	1.1	0.9	1.3	0.6	4.8	2.6
SW-1 Forest	-----	-----	-----	-----	-----	-----
SW-2 Upper	0.4	0.0	0.0	-----	-----	-----
SW-3 Lower	0.2	0.2	0.6	-----	-----	-----
SW-4 In-Lake	0.1	0.5	0.9	0.6	1.4	1.0
C-1 Forest	0.8	2.8	3.2	-----	-----	1.5
C-2 Upper	0.6	0.7	1.1	-----	4.1	1.9
C-3 Lower	0.9	0.4	0.8	-----	-----	2.1
C-4 In-Lake	0.3	0.8	1.2	0.7	-----	1.3
RG-3 Lower	-----	-----	-----	-----	-----	-----
RG-4 In-Lake	0.7	0.7	1.1	0.4	0.9	1.0
MH-1 Forest	2.6	0.1	0.5	0.8	68.6	2.3
MH-2 Upper	3.6	0.6	1.0	1.8	4.7	2.1
MH-3 Lower	2.1	0.0	0.4	0.3	3.5	2.2
MH-4 In-Lake	0.3	0.5	0.9	0.8	14.3	0.8
MH-1 Rt 16	14.5	0.3	0.7	-----	4.7	1.1
MH-1 Pristine	-----	1.4	1.0	0.5	22.7	3.0

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts.
(Turbidity Summary – average values)

Site	4/26/03 (NTU)	5/12/03 (NTU)	6/1/03 (NTU)	9/4/03 (NTU)	9/23/03 (NTU)	10/15/03 (NTU)
A-1 Forest	0.9	0.1	0.0	2.0	2.6	1.6
A-2 Upper	0.6	0.4	0.0	1.4	2.8	1.4
A-3 Lower	0.8	0.8	-----	-----	-----	-----
A-4 In-Lake	0.5	0.6	0.4	0.3	0.7	1.6
B-1 Forest	0.4	0.4	-----	0.7	1.8	1.0
B-2 Upper	0.3	0.2	0.0	0.8	1.9	1.0
B-3 Lower	0.4	0.5	0.2	0.8	3.9	1.3
B-4 In-Lake	0.4	0.3	0.4	0.5	2.1	1.0
SW-1 Forest	-----	-----	-----	-----	-----	-----
SW-2 Upper	0.3	0.2	0.1	-----	-----	-----
SW-3 Lower	0.3	0.3	0.2	-----	-----	-----
SW-4 In-Lake	0.4	0.4	0.4	0.4	0.8	0.7
C-1 Forest	0.5	0.3	0.6	-----	-----	-----
C-2 Upper	0.5	0.3	0.2	-----	2.7	1.6
C-3 Lower	0.5	0.3	0.2	-----	-----	-----
C-4 In-Lake	0.4	0.3	0.4	0.5	-----	-----
RG-3 Lower	-----	-----	-----	-----	-----	-----
RG-4 In-Lake	0.4	0.4	0.4	0.5	0.7	0.9
MH-1 Forest	1.2	0.2	0.2	0.9	6.7	1.4
MH-2 Upper	2.0	0.4	0.2	1.4	3.5	1.4
MH-3 Lower	1.1	0.3	0.2	0.7	2.2	1.4
MH-4 In-Lake	0.4	0.4	0.4	0.4	2.0	0.7
MH-1 Rt 16	9.2	0.5	-----	-----	10.9	1.6
MH-1 Pristine	-----	0.7	0.8	0.8	28.2	1.8

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts.
(Temperature Summary – average values)

Site	4/26/03 (°C)	5/12/03 (°C)	6/1/03 (°C)	9/4/03 (°C)	9/23/03 (°C)	10/15/03 (°C)
A-1 Forest	6.5	9.7	16.7	17.2	16.8	12.6
A-2 Upper	5.5	9.2	-----	16.9	16.7	12.7
A-3 Lower	6.1	8.8	10.2	-----	-----	12.8
A-4 In-Lake	6.6	13.3	-----	20.0	19.1	14.0
B-1 Forest	4.7	7.8	9.5	14.2	14.9	11.9
B-2 Upper	4.7	7.6	9.8	14.1	14.8	11.9
B-3 Lower	6.0	7.7	16.7	14.1	14.9	12.0
B-4 In-Lake	5.0	11.4	-----	20.4	18.8	14.2
SW-1 Forest	-----	-----	6.1	-----	-----	-----
SW-2 Upper	6.1	6.4	7.1	-----	-----	-----
SW-3 Lower	5.5	6.7	16.9	-----	14.5	-----
SW-4 In-Lake	6.5	13.1	9.7	20.2	19.4	14.0
C-1 Forest	4.9	8.2	8.7	-----	-----	12.0
C-2 Upper	4.9	8.1	9.5	-----	16.0	11.9
C-3 Lower	5.0	8.1	16.7	-----	15.6	12.0
C-4 In-Lake	5.8	11.9	-----	20.2	19.2	13.3
RG-3 Lower	-----	-----	17.2	-----	-----	-----
RG-4 In-Lake	6.6	13.3	11.4	20.1	19.3	13.8
MH-1 Forest	5.0	8.1	10.7	14.3	-----	11.9
MH-2 Upper	4.9	7.9	10.8	14.2	15.0	11.9
MH-3 Lower	5.0	7.9	17.0	14.3	14.8	12.0
MH-4 In-Lake	5.9	11.0	8.7	20.3	19.3	13.4
MH-1 Rt 16	5.3	7.1	8.7	14.6	16.1	12.4
MH-1 Pristine	-----	7.9	10.9	14.2	15.1	11.9

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts. (Specific Conductivity Summary – average values)

Site	4/26/03 (uS/cm)	5/12/03 (uS/cm)	6/1/03 (uS/cm)	9/4/03 (uS/cm)	9/23/03 (uS/cm)	10/15/03 (uS/cm)
A-1 Forest	-----	-----	-----	23.7	25.9	24.3
A-2 Upper	144.9	55.0	44.3	27.0	26.2	26.0
A-3 Lower	186.3	46.1	-----	-----	-----	25.2
A-4 In-Lake	51.9	42.2	31.6	39.4	42.6	40.5
B-1 Forest	19.1	19.2	-----	22.2	22.7	23.3
B-2 Upper	20.6	21.1	24.9	22.6	23.8	24.7
B-3 Lower	27.9	32.6	25.1	23.5	23.3	25.1
B-4 In-Lake	41.4	40.4	43.4	39.8	39.2	43.1
SW-1 Forest	-----	-----	-----	-----	-----	-----
SW-2 Upper	144.9	44.9	32.5	-----	-----	-----
SW-3 Lower	186.3	46.1	58.9	-----	50.5	-----
SW-4 In-Lake	51.9	42.2	47.2	39.8	39.6	41.2
C-1 Forest	19.1	19.2	21.6	-----	-----	23.4
C-2 Upper	20.6	21.1	23.4	-----	13.5	23.3
C-3 Lower	27.9	32.6	79.0	-----	13.2	23.4
C-4 In-Lake	41.4	40.4	44.7	41.3	39.4	35.7
RG-3 Lower	-----	-----	-----	-----	-----	-----
RG-4 In-Lake	55.1	44.9	42.8	39.7	39.3	42.6
MH-1 Forest	71.7	23.2	23.8	26.5	18.2	25.6
MH-2 Upper	88.5	66.9	114.0	49.9	36.4	28.7
MH-3 Lower	91.5	71.2	114.0	87.6	56.5	37.0
MH-4 In-Lake	72.4	53.5	44.6	41.6	42.1	40.8
MH-1 Rt 16	331.8	183.6	200.9	44.6	11.1	56.5
MH-1 Pristine	-----	42.7	55.9	24.6	22.2	24.4

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts. (Discharge Summary)

Site	Culvert A (gal/min)	Culvert B (gal/min)	Culvert C (gal/min)	Swale (gal/min)	MH Culvert (gal/min)	Rt 16 Culvert (gal/min)
4/26/03	-----	122.9	468.9	20.3	396.4	43.3
5/12/03	62.8	88.4	103.0	-----	234.5	-----
6/1/03	21.7	15.7	-----	-----	43.7	13.5
9/4/03	115.2	70.8	-----	-----	69.7	-----
9/23/03	415.5	306.4	504.4	-----	1031.4	489.4
10/15/03	197.5	259.4	716.4	-----	394.0	25.5

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts.
(Turbidity Summary – replicate values)

Site	4/26/03 Rep 1 (NTU)	4/26/03 Rep 2 (NTU)	5/12/03 Rep 1 (NTU)	5/12/03 Rep 2 (NTU)	6/1/03 Rep 1 (NTU)	6/1/03 Rep 2 (NTU)	9/4/03 Rep 1 (NTU)	9/4/03 Rep 2 (NTU)	9/23/03 Rep 1 (NTU)	9/23/03 Rep 2 (NTU)	10/15/03 Rep 1 (NTU)	10/15/03 Rep 2 (NTU)
A-1 Forest	0.9	0.9	0.1	0.1	-----	-----	2.0	2.0	2.6	2.6	1.6	1.6
A-2 Upper	0.6	0.7	0.4	0.3	0.0	0.1	1.4	1.4	2.8	2.8	1.4	1.4
A-3 Lower	0.7	0.9	0.8	0.7	-----	-----	-----	-----	-----	-----	1.5	1.5
A-4 In-Lake	0.4	0.5	0.6	0.6	0.4	0.4	0.3	0.3	0.7	0.6	1.6	1.6
B-1 Forest	0.4	0.4	0.4	0.5	-----	-----	0.7	0.7	2.0	1.6	1.0	1.0
B-2 Upper	0.3	0.3	0.2	0.2	0.0	0.1	0.8	0.9	1.9	1.9	1.0	1.1
B-3 Lower	0.4	0.4	0.5	0.5	0.2	0.2	0.8	0.8	4.0	3.8	1.3	1.3
B-4 In-Lake	0.4	0.4	0.4	0.3	0.4	0.5	0.4	0.5	2.0	2.1	1.0	1.0
SW-1 Forest	-----	-----	-----	-----	-----	-----	-----	-----	-----		-----	-----
SW-2 Upper	0.3	0.3	0.1	0.2	0.1	0.1	-----	-----	-----	-----	-----	-----
SW-3 Lower	0.3	0.3	0.2	0.3	0.1	0.2	-----	-----	-----	-----	-----	-----
SW-4 In-Lake	0.4	0.3	0.5	0.4	0.4	0.4	0.4	0.5	0.8	0.8	0.7	0.8
C-1 Forest	0.5	0.5	0.3	0.4	0.5	0.6	-----	-----	-----	-----	1.5	1.5
C-2 Upper	0.5	0.5	0.3	0.4	0.2	0.3	-----	-----	2.6	2.8	1.6	1.6
C-3 Lower	0.5	0.5	0.3	0.3	0.2	0.2	-----	-----	-----	-----	1.6	1.6
C-4 In-Lake	0.4	0.5	0.3	0.3	0.4	0.4	0.5	0.5	-----	-----	1.0	1.0
RG-3 Lower	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
RG-4 In-Lake	0.4	0.5	0.4	0.3	0.4	0.4	0.4	0.5	0.7	0.6	0.9	0.8
MH-1 Forest	1.1	1.2	0.2	0.2	0.2	0.2	0.9	0.9	6.1	7.2	1.4	1.5
MH-2 Upper	2.1	2.0	0.4	0.4	0.2	0.2	1.5	1.4	3.6	3.4	1.4	1.4
MH-3 Lower	1.1	1.2	0.3	0.3	0.2	0.2	0.7	0.6	2.2	2.3	1.3	1.4
MH-4 In-Lake	0.5	0.4	0.4	0.5	0.4	0.4	0.4	0.4	1.9	2.1	0.7	0.7
MH-1 Rt 16	9.0	9.4	0.5	0.5	-----	-----	-----	-----	10.3	11.5	1.6	1.6
MH-1 Pristine	-----	-----	0.7	0.6	-----	-----	-----	-----	28.0	28.3	1.8	1.9

Task 1. Post BMP Installation Monitoring/Evaluation of the Route 16 Culverts. (Temperature Summary – replicate values)

Site	4/26/03 Rep 1 (°C)	4/26/03 Rep 2 (°C)	5/12/03 Rep 1 (°C)	5/12/03 Rep 2 (°C)	6/1/03 Rep 1 (°C)	6/1/03 Rep 2 (°C)	9/4/03 Rep 1 (°C)	9/4/03 Rep 2 (°C)	9/23/03 Rep 1 (°C)	9/23/03 Rep 2 (°C)	10/15/03 Rep 1 (°C)	10/15/03 Rep 2 (°C)
A-1 Forest	6.5	6.5	9.7	9.7	16.7	16.7	17.2	17.2	16.8	16.8	12.6	12.6
A-2 Upper	5.5	5.5	9.2	9.2	-----	-----	16.9	16.9	16.7	16.7	12.7	12.7
A-3 Lower	6.1	6.1	8.8	8.8	10.2	10.2	-----	-----	-----	-----	12.8	12.8
A-4 In-Lake	6.6	6.6	13.3	13.2	-----	-----	19.9	20.0	19.1	19.1	14.0	14.0
B-1 Forest	4.7	4.7	7.8	7.8	9.5	9.5	14.2	14.2	14.9	14.8	11.9	11.9
B-2 Upper	4.7	4.7	7.6	7.6	9.7	9.8	14.1	14.1	14.8	14.8	11.9	11.9
B-3 Lower	5.9	6.0	7.7	7.6	16.6	16.8	14.1	14.1	14.9	14.8	12.0	12.0
B-4 In-Lake	4.9	5.0	11.2	11.5	-----	-----	20.4	20.4	19.0	18.6	14.2	14.2
SW-1 Forest	-----	-----	-----	-----	6.1	6.1	-----	-----	-----	-----	-----	-----
SW-2 Upper	6.1	6.1	6.4	6.4	7.1	7.1	-----	-----	-----	-----	-----	-----
SW-3 Lower	5.5	5.5	6.7	6.6	16.9	16.9	-----	-----	14.5	14.5	-----	-----
SW-4 In-Lake	6.5	6.5	13.0	13.1	9.7	9.7	20.2	20.2	19.3	19.4	14.0	14.0
C-1 Forest	4.9	4.9	8.2	8.2	8.7	8.6	-----	-----	-----	-----	11.9	12.0
C-2 Upper	4.9	4.9	8.1	8.1	9.5	9.5	-----	-----	16.0	16.0	11.9	11.9
C-3 Lower	5.0	5.0	8.1	8.1	16.7	16.7	-----	-----	15.6	15.6	12.0	12.0
C-4 In-Lake	5.8	5.8	12.2	11.5	-----	-----	20.2	20.2	19.2	19.2	13.2	13.4
RG-3 Lower	-----	-----	-----	-----	17.2	17.2	-----	-----	-----	-----	-----	-----
RG-4 In-Lake	6.6	6.6	13.2	13.3	11.4	11.4	20.1	20.1	19.3	19.3	13.8	13.8
MH-1 Forest	5.0	5.0	8.1	8.1	10.6	10.7	14.3	14.3	15.5	15.5	11.9	11.9
MH-2 Upper	4.9	4.9	7.9	7.9	10.8	10.8	14.2	14.2	15.0	15.0	11.9	11.9
MH-3 Lower	5.0	5.0	7.9	7.9	17.0	17.0	14.3	14.3	14.8	14.8	12.0	11.9
MH-4 In-Lake	5.9	5.8	11.6	10.4	8.7	8.7	20.3	20.3	19.3	19.3	13.4	13.4
MH-1 Rt 16	5.3	5.3	7.1	7.1	8.7	8.7	14.6	14.6	16.1	16.1	12.4	12.4
MH-1 Pristine	-----	-----	7.9	7.9	10.9	10.8	14.2	14.2	15.1	15.1	11.9	11.9

Task II - Deep Lake and Major Tributary Sampling.
(Total Phosphorus summary)

Date	Chocorua River Inlet (Inlet) Total Phosphorus (*ug*/L)	Site 1 South (1 Deep) Total Phosphorus (*ug*/L)	Chocorua Bridge (Bridge) Total Phosphorus (*ug*/L)
5/22/03	3.5	4.0	3.4
6/10/03	4.8	3.5	3.7
6/20/03	-----	4.8	-----
6/27/03	5.5	4.6	-----
7/3/03	-----	5.2	-----
7/14/03	-----	5.1	-----
8/8/03	5.0	6.1	4.0
8/21/03	5.7	5.4	4.7
9/3/03	6.1	5.9	5.0
9/18/03	5.2	4.2	4.8

Task III - Integrated Nutrient Sampling of Pre and Post Wetland Impacts

Total Phosphorus Summary

Sampling Station	5/29/03 TP (ug/L)	6/18/03 TP (ug/L)	7/3/03 TP (ug/L)	7/17/03 TP (ug/L)	7/31/03 TP (ug/L)	8/14/03 TP (ug/L)	8/29/03 TP (ug/L)	9/11/03 TP (ug/L)	10/7/03 TP (ug/L)
1 Protected	1.5	4.9	1.7	1.5	1.6	1.8	0.9	1.0	1.1
2 Drake Hill	1.1	1.8	1.8	2.0	1.5	2.0	1.0	1.0	0.8
3 Wash Hill	3.7	11.6	18.1	9.1	21.1	6.2	9.2	5.3	3.1
4 Korsons	4.1	5.7	11.4	12.5	10.7	7.0	7.4	6.0	3.7
5 Griffiths	3.5	4.4	7.3	7.7	8.7	6.2	5.3	7.3	3.0
6 River Mouth (Choc. Rvr)	4.4	5.1	-----	-----	-----	4.9	-----	-----	4.1
7 Lottoral Zone (Toby)	5.1	3.8	-----	-----	-----	5.0	-----	4.3	-----
8 Dam (outlet)	3.6	4.3	4.4	5.1	5.0	4.9	4.5	3.8	4.1

Soluble Reactive Phosphorus Summary

Sampling Station	5/29/03 SRP (ug/L)	6/18/03 SRP (ug/L)	7/3/03 SRP (ug/L)	7/17/03 SRP (ug/L)	7/31/03 SRP (ug/L)	8/14/03 SRP (ug/L)	8/29/03 SRP (ug/L)	9/11/03 SRP (ug/L)	10/7/03 SRP (ug/L)
1 Protected	0.6	1.0	1.1	0.4	1.0	1.1	0.4	0.6	0.7
2 Drake Hill	1.7	1.6	1.2	0.4	1.2	1.2	0.5	0.6	0.7
3 Wash Hill	1.4	1.1	1.9	0.6	1.9	1.6	0.7	0.5	1.1
4 Korsons	1.3	1.3	1.2	0.8	1.0	1.9	1.1	0.5	1.0
5 Griffiths	0.7	1.2	1.4	0.7	1.0	1.8	1.2	0.8	0.9
6 River Mouth (Choc. Rvr)	0.4	0.7	-----	-----	-----	1.5	-----	-----	0.7
7 Lottoral Zone (Toby)	0.0	0.7	-----	-----	-----	0.8	-----	0.3	-----
8 Dam (outlet)	0.5	0.7	0.7	0.2	0.6	1.1	0.4	0.3	0.9

Task III - Integrated Nutrient Sampling of Pre and Post Wetland Impacts

Total Nitrogen Summary

Sampling Station	5/29/03 TN (ug/L)	6/18/03 TN (ug/L)	7/3/03 TN (ug/L)	7/17/03 TN (ug/L)	7/31/03 TN (ug/L)	8/14/03 TN (ug/L)	8/29/03 TN (ug/L)	9/11/03 TN (ug/L)	10/7/03 TN (ug/L)
1 Protected	44	67	68	-----	31	98	15	49	53
2 Drake Hill	49	29	44	-----	28	132	106	77	14
3 Wash Hill	145	143	264	-----	196	261	193	165	182
4 Korsons	126	157	181	-----	148	265	118	188	74
5 Griffiths	122	87	144	-----	153	206	137	226	90
6 River Mouth (Choc. Rvr)	203	134	135	-----	-----	203	-----	-----	123
7 Lottoral Zone (Toby)	144	108	175	-----	-----	245	-----	184	-----
8 Dam (outlet)	83	109	-----	-----	145	224	158	176	185

Temperature Summary

Sampling Station	5/29/03 Temp (°C)	6/18/03 Temp (°C)	7/3/03 Temp (°C)	7/17/03 Temp (°C)	7/31/03 Temp (°C)	8/14/03 Temp (°C)	8/29/03 Temp (°C)	9/11/03 Temp (°C)	10/7/03 Temp (°C)
1 Protected	9.1	10.8	14.2	14.1	14.3	14.9	12.2	12.5	6.8
2 Drake Hill	9.2	11.0	14.5	14.3	14.4	15.0	12.3	12.8	6.9
3 Wash Hill	13.4	17.7	19.8	19.3	18.7	17.8	15.5	14.8	6.3
4 Korsons	14.0	16.8	21.2	19.4	17.6	18.1	15.9	16.2	7.7
5 Griffiths	12.9	14.5	17.0	16.0	15.5	17.6	13.9	14.0	7.5
6 River Mouth (Choc. Rvr)	16.9	-----	-----	-----	-----	-----	-----	-----	-----
7 Lottoral Zone (Toby)	15.8	-----	-----	-----	-----	-----	-----	-----	-----
8 Dam (outlet)	16.7	21.1	-----	24.1	24.3	25.8	22.8	22.6	13.4

Task III - Integrated Nutrient Sampling of Pre and Post Wetland Impacts

Specific Conductivity @ 25°C Summary

Sampling Station	5/29/03 SPCD (us/cm)	6/18/03 SPCD (us/cm)	7/3/03 SPCD (us/cm)	7/17/03 SPCD (us/cm)	7/31/03 SPCD (us/cm)	8/14/03 SPCD (us/cm)	8/29/03 SPCD (us/cm)	9/11/03 SPCD (us/cm)	10/7/03 SPCD (us/cm)
1 Protected	31.8	33.2	35.4	35.6	37.8	23.2	32.1	33.8	28.0
2 Drake Hill	31.7	34.4	36.4	37.6	38.2	26.2	34.1	35.8	28.6
3 Wash Hill	48.1	56.6	71.1	60.4	79.2	30.1	57.9	58.7	42.7
4 Korsons	45.0	51.3	62.5	60.4	66.2	37.2	57.1	58.4	44.1
5 Griffiths	39.6	43.3	45.7	48.0	49.0	33.4	44.3	47.0	39.5
6 River Mouth (Choc. Rvr)	40.5	-----	-----	-----	-----	-----	-----	-----	38.8
7 Lottoral Zone (Toby)	40.7	-----	-----	-----	-----	-----	-----	40.6	-----
8 Dam (outlet)	42.8	43.9	-----	43.8	43.0	41.5	41.8	41.2	41.4

Turbidity Summary

Sampling Station	5/29/03 Turbidity (NTU)	6/18/03 Turbidity (NTU)	7/3/03 Turbidity (NTU)	7/17/03 Turbidity (NTU)	7/31/03 Turbidity (NTU)	8/14/03 Turbidity (NTU)	8/29/03 Turbidity (NTU)	9/11/03 Turbidity (NTU)	10/7/03 Turbidity (NTU)
1 Protected	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0
2 Drake Hill	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.2
3 Wash Hill	0.3	0.8	3.8	2.3	3.6	0.6	1.7	1.3	0.6
4 Korsons	0.4	0.9	3.1	3.6	3.2	0.6	2.1	1.6	0.9
5 Griffiths	0.3	0.5	1.5	1.4	1.6	0.6	1.2	1.3	0.7
6 River Mouth (Choc. Rvr)	0.3	0.4	-----	-----	-----	0.6	-----	-----	1.1
7 Lottoral Zone (Toby)	0.4	0.3	-----	-----	-----	0.5	-----	0.3	-----
8 Dam (outlet)	0.3	0.5	1.0	0.5	0.6	0.5	0.5	0.4	0.9

Task III - Integrated Nutrient Sampling of Pre and Post Wetland Impacts
(Temperature Summary – replicate values)

Sampling Location	5/29/03 Rep 1 Temp (°C)	5/29/03 Rep 2 Temp (°C)	6/18/03 Rep 1 Temp (°C)	6/18/03 Rep 2 Temp (°C)	7/3/03 Rep 1 Temp (°C)	7/3/03 Rep 2 Temp (°C)
1 Protected	9.1	9.1	10.8	10.8	14.3	14.0
2 Drake Hill	9.2	9.2	11.0	11.0	14.5	14.5
3 Wash Hill	13.4	13.4	17.7	17.7	19.7	19.9
4 Korsons	13.9	14.0	16.8	16.8	21.2	21.2
5 Griffiths	12.9	12.9	14.5	14.5	16.8	17.1
6 River Mouth (Choc. Rvr)	16.9	16.8	-----	-----	-----	-----
7 Lottoral Zone (Toby)	15.7	15.8	-----	-----	27.1	27.0
8 Dam (outlet)	16.7	16.6	21.1	21.1	-----	-----

Sampling Location	7/17/03 Rep 1 Temp (°C)	7/17/03 Rep 2 Temp (°C)	7/31/03 Rep 1 Temp (°C)	7/31/03 Rep 2 Temp (°C)	8/14/03 Rep 1 Temp (°C)	8/14/03 Rep 2 Temp (°C)
1 Protected	14.1	14.0	14.3	14.2	14.9	14.9
2 Drake Hill	14.3	14.3	14.4	14.3	15.0	14.9
3 Wash Hill	19.3	19.3	18.7	18.6	17.8	17.8
4 Korsons	19.4	19.4	17.6	17.6	18.1	18.1
5 Griffiths	15.9	16.0	15.5	15.5	17.5	17.6
6 River Mouth (Choc. Rvr)	-----	-----	-----	-----	-----	-----
7 Lottoral Zone (Toby)	-----	-----	-----	-----	-----	-----
8 Dam (outlet)	24.1	24.1	24.2	24.3	25.8	25.8

Sampling Location	8/29/03 Rep 1 Temp (°C)	8/29/03 Rep 2 Temp (°C)	9/11/03 Rep 1 Temp (°C)	9/11/03 Rep 2 Temp (°C)	10/7/03 Rep 1 Temp (°C)	10/7/03 Rep 2 Temp (°C)
1 Protected	12.2	12.2	12.5	12.5	6.8	6.8
2 Drake Hill	12.3	12.3	12.8	12.8	6.8	6.9
3 Wash Hill	15.5	15.5	14.8	14.8	6.3	6.3
4 Korsons	15.8	15.9	16.1	16.2	7.7	7.7
5 Griffiths	13.9	13.9	14.0	13.9	7.5	7.4
6 River Mouth (Choc. Rvr)	-----	-----	-----	-----	-----	-----
7 Lottoral Zone (Toby)	-----	-----	-----	-----	-----	-----
8 Dam (outlet)	22.7	22.8	22.6	22.5	13.4	13.4

Task III - Integrated Nutrient Sampling of Pre and Post Wetland Impacts
(Specific Conductivity Summary – replicate values)

Sampling Locations	5/29/03 Rep 1 (SPCD)	5/29/03 Rep 2 (SPCD)	6/18/03 Rep 1 (SPCD)	6/18/03 Rep 2 (SPCD)	7/3/03 Rep 1 (SPCD)	7/3/03 Rep 2 (SPCD)
1 Protected	31.8	31.7	33.2	33.2	36.5	34.2
2 Drake Hill	31.9	31.5	34.4	34.4	36.3	36.4
3 Wash Hill	48.4	47.8	56.6	56.6	71.0	71.1
4 Korsons	45.0	44.9	51.3	51.3	62.6	62.4
5 Griffiths	39.6	39.5	43.3	43.3	45.7	45.6
6 River Mouth (Choc. Rvr)	40.5	40.4	-----	-----	-----	-----
7 Lottoral Zone (Toby)	40.8	40.6	-----	-----	45.7	45.4
8 Dam (outlet)	42.7	42.8	43.9	43.9	-----	-----

Sampling Locations	7/17/03 Rep 1 (SPCD)	7/17/03 Rep 2 (SPCD)	7/31/03 Rep 1 (SPCD)	7/31/03 Rep 2 (SPCD)	8/14/03 Rep 1 (SPCD)	8/14/03 Rep 2 (SPCD)
1 Protected	35.5	35.6	38.1	37.5	21.1	25.3
2 Drake Hill	38.1	37.1	38.2	38.1	26.2	26.2
3 Wash Hill	60.5	60.3	80.2	78.1	30.1	30.0
4 Korsons	60.5	60.2	66.2	66.2	37.2	37.1
5 Griffiths	48.0	48.0	48.8	49.1	33.5	33.3
6 River Mouth (Choc. Rvr)	-----	-----	-----	-----	-----	-----
7 Lottoral Zone (Toby)	-----	-----	-----	-----	-----	-----
8 Dam (outlet)	43.8	43.7	43.0	43.0	41.4	41.5

Sampling Locations	8/29/03 Rep 1 (SPCD)	8/29/03 Rep 2 (SPCD)	9/11/03 Rep 1 (SPCD)	9/11/03 Rep 2 (SPCD)	10/7/03 Rep 1 (SPCD)	10/7/03 Rep 2 (SPCD)
1 Protected	32.1	32.0	33.8	33.8	27.9	28.0
2 Drake Hill	34.1	34.0	35.8	35.7	27.8	29.4
3 Wash Hill	58.0	57.8	58.7	58.6	42.7	42.7
4 Korsons	57.2	57.0	58.4	58.3	44.1	44.1
5 Griffiths	44.3	44.3	47.0	46.9	39.5	39.4
6 River Mouth (Choc. Rvr)	-----	-----	-----	-----	38.8	38.8
7 Lottoral Zone (Toby)	-----	-----	40.6	40.6	-----	-----
8 Dam (outlet)	41.7	41.8	41.2	41.2	41.4	41.4

Task III - Integrated Nutrient Sampling of Pre and Post Wetland Impacts
(Turbidity Summary – replicate values)

Sampling Locations	5/29/03 Rep 1 (NTU)	5/29/03 Rep 2 (NTU)	6/18/03 Rep 1 (NTU)	6/18/03 Rep 2 (NTU)	7/3/03 Rep 1 (NTU)	7/3/03 Rep 2 (NTU)
1 Protected	0.00	0.00	0.02	0.02	0.05	0.10
2 Drake Hill	0.00	0.00	0.06	0.06	0.05	0.05
3 Wash Hill	0.34	0.34	0.82	0.82	3.70	3.90
4 Korsons	0.38	0.38	0.88	0.88	3.10	3.10
5 Griffiths	0.29	0.29	0.54	0.55	1.50	1.50
6 River Mouth (Choc. Rvr)	0.30	0.31	0.44	0.44	-----	-----
7 Lottoral Zone (Toby)	0.41	0.41	0.33	0.34	-----	-----
8 Dam (outlet)	0.30	0.30	0.52	0.53	1.20	0.85

Sampling Locations	7/17/03 Rep 1 (NTU)	7/17/03 Rep 2 (NTU)	7/31/03 Rep 1 (NTU)	7/31/03 Rep 2 (NTU)	8/14/03 Rep 1 (NTU)	8/14/03 Rep 2 (NTU)
1 Protected	0.00	0.00	0.10	0.00	0.07	0.07
2 Drake Hill	0.05	0.05	0.10	0.00	0.11	0.09
3 Wash Hill	2.30	2.20	3.60	3.60	0.57	0.58
4 Korsons	3.70	3.50	3.10	3.20	0.64	0.62
5 Griffiths	1.40	1.40	1.50	1.60	0.54	0.60
6 River Mouth (Choc. Rvr)	-----	-----	-----	-----	0.58	0.57
7 Lottoral Zone (Toby)	-----	-----	-----	-----	0.52	0.49
8 Dam (outlet)	0.50	0.45	0.60	0.60	0.53	0.55

Sampling Locations	8/29/03 Rep 1 (NTU)	8/29/03 Rep 2 (NTU)	9/11/03 Rep 1 (NTU)	9/11/03 Rep 2 (NTU)	10/7/03 Rep 1 (NTU)	10/7/03 Rep 2 (NTU)
1 Protected	0.00	0.00	0.00	0.00	0.01	0.01
2 Drake Hill	0.00	0.00	0.00	0.00	0.18	0.18
3 Wash Hill	1.75	1.74	1.35	1.34	0.62	0.65
4 Korsons	2.06	2.11	1.55	1.55	0.90	0.92
5 Griffiths	1.24	1.25	1.32	1.30	0.69	0.72
6 River Mouth (Choc. Rvr)	-----	-----	-----	-----	1.08	1.04
7 Lottoral Zone (Toby)	-----	-----	0.32	0.31	-----	-----
8 Dam (outlet)	0.48	0.46	0.35	0.35	0.85	0.86

Task III - Integrated Nutrient Sampling of Pre and Post Wetland Impacts
(Discharge Data)

Site	5/29/03 (m^3/min)	6/18/03 (m^3/min)	7/3/03 (m^3/min)	7/17/03 (m^3/min)	7/31/03 (m^3/min)	8/14/03 (m^3/min)	8/29/03 (m^3/min)	9/11/03 (m^3/min)	10/7/03 (m^3/min)
1 Protected	0.2265	0.1425	0.0676	0.0559	0.0439	0.5388	0.0965	0.0608	0.1982
2 Drake Hill	0.2924	0.1351	------	0.0481	0.0494	0.3915	0.0649	0.0440	0.1380
3 Wash Hill	0.2288	0.1338	------	0.0424	0.0355	0.3541	0.0610	0.0534	0.1842
4 Korsons	0.5797	0.1681	0.0323	0.0636	0.0571	0.8970	0.1385	0.0910	0.3460
5 Griffiths	0.6352	0.2828	------	0.0755	0.0886	1.1374	0.1266	0.1237	0.3364
6 River Mouth (Choc. Rvr)	------	------	------	------	------	------	------	------	------
7 Lottoral Zone (Toby)	------	------	------	------	------	------	------	------	------
8 Dam (outlet)	1.1276	0.2851	------	0.3414	0.2262	1.4774	0.2373	0.2476	0.4485

Task III – Periphyton Biomass at Pre and Post Wetland sampling sites

Site & Date	06/18/03 (ug/m^2)	07/03/03 (ug/m^2)	07/18/03 (ug/m^2)	08/14/03 (ug/m^2)	09/12/03 (ug/m^2)
1 Protected	25.6	15.3	11.2	------	9.7
2 Drake Hill	818.2	1388.1	731.7	607.4	585.8
3 Wash Hill	1000.2	459.3	1021.3	4572.0	1308.6
4 Korsons	954.9	5452.6	5033.3	------	4976.2
5 Griffiths	823.3	695.3	1434.8	1274.7	672.7
8 Dam (outlet)	442.9	2430.4	3175.1	2430.4	2356.4